European Commission

Monitoring industrial ecosystems

AGRI-FOOD

Analytical report – 2024 Edition

This report was prepared by Els Van de Velde, Daniela Kretz and Laura Lecluyse, IDEA Consult and Carmen Moreno and Kincsö Izsak, Technopolis Group for the European Commission Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs. However, it does not necessarily reflect the views of the European Commission.

EUROPEAN COMMISSION

Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs
Directorate B – Simplification and networks
Unit GROW.B.4 – Industrial Forum, Alliances and Clusters

European Innovation Council and SMEs Executive Agency (EISMEA)
Unit I.02 - SMP/SME Pillar, Internal Market and Support to Standardisation
E-Mail: EISMEA-SMP-COSME-ECOSYSTEMS@ec.europa.eu

European Commission
B-1049 Brussels

PDF	ISBN: 978-92-9412-168-4	doi: 10.2826/4766674	EA-01-25-093-EN-N

Luxembourg: Publications Office of the European Union, 2025

TABLE OF CONTENTS

TABLE OF FIGURES

Executive Summary

This report has been prepared within the 'European Monitor of Industrial Ecosystems' (EMI) project with the objective to analysing the green and digital transformation of industrial ecosystems and progress made over time, in this specific case agri-food.

The second edition of the Industrial Ecosystems series has divided the analysis into two sections meaning, 'green transition' and 'digital transition' followed by three subsections each showing: a) industry efforts, b) framework conditions and c) the impact on the environment and on productivity.

The key findings of this year's analysis are being presented below:

Green Transition

What progress has the industry made in taking action for the environment?

- The share of patent applications in the agri-food industrial ecosystem **tends to be lower** compared to other ecosystems. Consequently, patents are typically concentrated in specific technological fields such as **biotechnology**.

- In 2024, **32% of companies in the agri-food industrial ecosystem have adopted strategies for climate neutrality**, showing a modest commitment.

- Agri-food companies have been actively implementing measures to **enhance material conservation** with **good progress from 2021 to 2024,** increasing from 58% to nearly 70%. This was followed closely by energy-saving initiatives, adopted by 65% of companies, and waste minimisation efforts, embraced by 62% of companies in 2024.

- **49% of agri-food companies focused on conserving water within their operations.** These measures highlight the industry's prioritisation of resource efficiency as part of its green transition efforts. The shift from minimising waste to saving materials highlights the importance of circular thinking in the agri-food industrial ecosystem and a shift along this mentality.

- Environmental startups in agri-food are led by business models in the areas of **healthy food** and **alternative proteins,** with 297 and 244 startups created in these areas, respectively over the period 2015-2022. In addition, startups also focus on biotechnology and renewable energy in the agri-food industrial ecosystem.

- **Investments in resource efficiency are not prioritised by 29% of agri-food companies, while 46% of companies invest less than 5% of annual revenue in resource efficiency.** The majority of companies invest less than 1% or between 1 and 5% of annual turnover in environmental technologies and measures (56%). These results suggest that own financial resources in agri-food will not be enough to finance green transformation of the agri-food industrial ecosystem.

- **Venture capital investments** lie predominantly in the area of **alternative proteins** over the period 2015-2023, highlighting the relative importance of alternative proteins as a topic for young companies.

To what extent do framework conditions such as public financing and skills support the green transition?

- The agri-food industrial ecosystem received **EUR 15.25 bn in support from the European Regional Development Fund** for the period 2014-2020. Projects that addressed specifically the **green transition of tourism accounted for over EUR 5.19 bn.**

- **31% of the identified agri-food projects contribute to the green transition, while 9%** support the implementation of measures of **energy efficiency** and demonstration projects in SMEs and large companies.

- While the **Horizon 2020 programme funded EUR 1.3 bn** to projects classified under the agri-food industrial ecosystem, **Horizon Europe** has thus far provided **EUR 670.3 m** in funding. For **Horizon Europe, 42% of the European funding** to agri-food projects contributes to the green transition thus far.

- **Critical skills gaps in the agri-food industrial ecosystem relate to sustainability skills, efficient use of resources and logistics skills, and bioeconomy related skills.** The share of professionals registered on LinkedIn and employed in the agri-food industrial ecosystem with skills relevant to the green transition attained 2.3% in 2024, down from 3.2% in 2022.

How is the industrial ecosystem's impact on the environment changing?

- The **agri-food industrial ecosystem is addressing its emissions-related challenges** while continuing to face significant challenges in other environmental areas. In particular, the sector **still lags behind in its impact on material extraction, water usage, and waste generation**.

- The share of agri-food in emissions from all sectors decreased from **37% in 2001 to 30% in 2021** due to faster growth in non-food emissions. Total emissions produced in the agri-food industrial ecosystem in the EU are following **a decreasing trend, with 1.32 gigatonnes of CO_2 equivalent (Gt CO_2eq) in 2001 to 1.16 Gt CO_2eq in 2021.**

- About **30%** of the world's energy is **consumed within agri-food**, and this energy use is responsible for one-third of the sector's greenhouse gas emissions. Energy intensity is also growing due to increased mechanisation, growing use of fossil fuel–based inputs, including pesticides and fertilizers and increasingly globalized supply chains.

- In the EU, many countries are at risk of **water scarcity** and vast parts of the continent having suffered severe droughts over the past years. Agricultural areas with intensive irrigation, islands in southern Europe, and large urban agglomerations are deemed to be the biggest **water stress hotspots.** While only around **9 % of Europe's total farmland is irrigated**, these areas still **account for about 50 % of total water use in Europe.**

Digital Transition

What is the progress of industrial efforts towards digitalisation?

- The share of digital related patenting activities in the industrial ecosystem lies **under the anticipated agri-food industrial ecosystem average** of 10%, with figures ranging between 2.5% and 5%. This can be explained by the fact that patents supporting the digital transition may be developed in other industrial ecosystems.

- **20% of companies had a concrete strategy in place for digital transformation** in the agri-food industrial ecosystem in 2024.

- The uptake of **Cloud, Internet of Things, Artificial Intelligence, and Robotics technologies** by agri-food businesses have increased since 2023. 73% of businesses that adopted AI did so within the past two years. **19% of companies use AI in the design and planning stage.** AI innovations are expected to **inform management decisions, improve efficiency, reduce waste, and enhance the overall sustainability** of the agri-food industrial ecosystem.

- **Startups active in the area of AI and big data lead the startup creation** with a total of 307 startups formed between 2015 and 2023.

- **The vast majority of agri-food companies invest less than 5% of their annual turnover into digital technologies**. A few select technologies are prioritized by companies investing more than 30% of their annual turnover, including in artificial intelligence (3.23%), IoT (5.41%) and robotics (12.5%).

To what extent do framework conditions such as public financing and skills support the digital transition?

- The European Regional Development Fund (ERDF) plays a vital role in the digital transition of the agri-food industrial ecosystem. Over the period 2014-2020, **about 10% (or EUR 1.59 bn) of the funding to agri-food ERDF projects supported the digital transition.**

- **26.1% of the Horizon 2020 funding to agri-food projects contributed to the digital transition**. In Horizon Europe, 18.1% of the funding contributed to agri-food projects related to the digital transition from 2022 to 2024.

- In 2024, **2% of professionals registered on LinkedIn and employed within the agri-food industrial ecosystem possessed advanced digital skills and 15.1% possessed other more moderate digital skills, marking an increase from the levels observed in 2022**. This suggests progress in the overall digital competency, while the adoption of more advanced digital expertise has yet to experience significant growth.

- **Requirements for digital skills listed on online job advertisements within agri-food has been growing** over the period from 2019-2023. 12% of the job advertisements included a requirement of advanced digital skill such as **AI, big data, augmented and virtual reality, cloud**, compared to 25% of the job advertisements requiring moderate digital skills.

What is the impact of digital technologies on competitiveness?

- Digital technologies support in **increasing the competitiveness** of the agri-food industrial ecosystem by finding **efficiency gains in production**, while at the same time increasing **resilience** and **limiting the impact of the industry** on the environment, while also enabling safety, security, traceability and the production of higher quality food products.

- The EU is an agricultural production leader, especially in segment of precision farming technologies. Further opportunities lie in **connecting technology developers with agri-food industrial ecosystem players** to adapt existing technologies to the specific needs.

- The **adoption of advanced digital technologies has led to a notable 10% increase in productivity,** as measured by output per hour worked for the agri-food industrial ecosystem. Among the technologies driving this productivity boost, robotics was identified by respondents as having the greatest impact.

1. Introduction

1.1. Objectives

This report has been prepared within the '**European Monitor of Industrial Ecosystems' (EMI)** project, initiated by the European Commission, Directorate General for Internal Market, Industry, Entrepreneurship and SMEs and the European Innovation Council and SMEs Executive Agency (EISMEA). The overall objective of the project is to **contribute to the analysis of the green and digital transformation of industrial ecosystems** and progress made over time.

The EU's updated industrial strategy[1] has identified 14 industrial ecosystems[2] – one of them being **'Agri-Food'** - that is the focus of this report. The industrial strategy defined industrial ecosystems as encompassing all players operating in a value chain: from the smallest startups to the largest companies, from academia to research, service providers to suppliers. The notion of ecosystems captures the complex set of interlinkages and interdependencies among sectors and firms across the EU. Industrial transition is driven by technological, economic, and social changes, and by the adoption of green and digital technologies and that move towards sustainable competitiveness. The process is however characterised by complex, multi-level, and dynamic developments. To make transition sustainable, technological change needs to be coupled with new business models, the necessary investments and financial tools, skills, regulatory framework conditions and behavioural change across the ecosystem.

The indicator framework includes a **set of traditional and novel data sources that shed new light on ongoing transformation patterns.** The novelty of the analysis lies in the exploratory and innovative data sources used across the different chapters of the report. Due to its effort to analyse industrial ecosystems using a standardised set of indicators, the study cannot address all aspects of the green and digital transition. Therefore, additional analysis and industry-specific data sources should be used to supplement a full assessment.

Measuring performance and change is vital to allow policymakers and industry stakeholders to track progress over time and get feedback on whether the system is moving in the desired direction. To measure performance, a dedicated **monitoring and indicator framework** has been set up for the purposes of this project with an aim to capture data in regular intervals (see the overview of the monitoring framework in Figure 1).

The **methodological report** that sets the conceptual basis and explains the technical details of each indicator is found in a separate document uploaded on the EMI website. Moreover, some of the specific industry codes used throughout this analysis have been included in Appendix B.

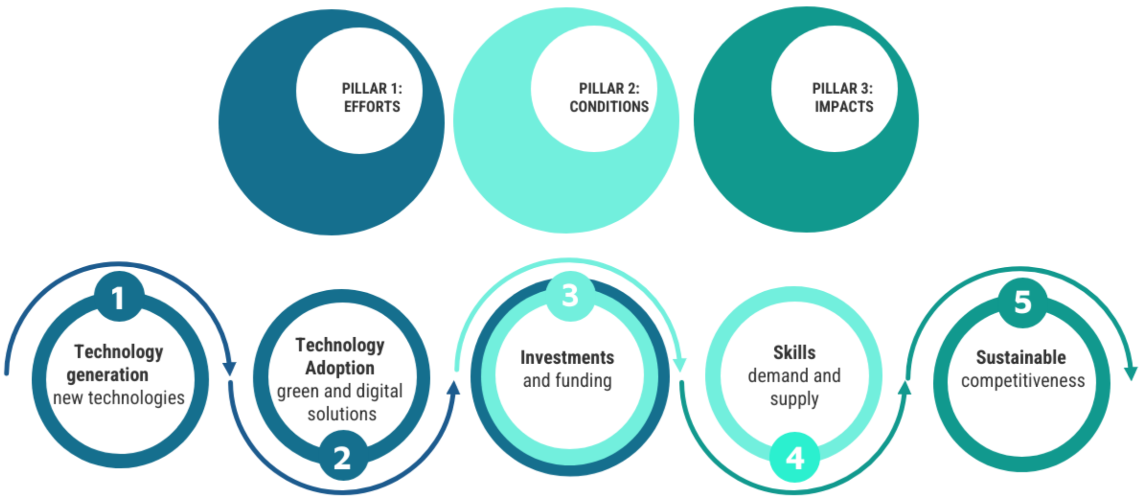
The green and digital technologies considered in this study include the following:

- *Green transition technologies*: advanced materials, biotechnology, clean production technologies, energy saving technologies, recycling technologies, renewable energy.
- *Advanced digital technologies*: advanced manufacturing and robotics, artificial intelligence and big data, augmented and virtual reality, blockchain, cloud computing, Internet of Things, digital security.

[1] European Commission (2020) A New Industrial Strategy for Europe, COM/2020/102 final and European Commission (2021). Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe's recovery, COM(2021) 350 final. Retrieved from: https://knowledge4policy.ec.europa.eu/publication/communication-com2020102-new-industrial-strategy-europe_en#:~:text=To%20uphold%20Europe's%20industrial%20leadership,%20a

[2] The 14 industrial ecosystems include: construction, digital industries, health, agri-food, renewables, energy intensive industries, transport and automotive, electronics, textile, aerospace and defence, cultural and creative culture industries, tourism, proximity and social economy, and retail

Figure 1: Overview of monitoring industrial ecosystems and relevant data sources



- Technology generation
  Patent data
- Technology centres
  TC mapping

- Technology adoption
  CATI Survey
  Big Data
- Technology and new business models
  Startup data

- Private investments
  Capital investments
- Public investments
  ERDF and CORDA data

- Skills supply
  LinkedIn data
- Skills demand
  Cedefop data

- Environmental performance
  Exiobase data,
  Waste statistics
- Digital performance
  CATI Survey
- Industrial performance
  Prodcom and Trade

Source: Technopolis Group, IDEA Consult and Fraunhofer ISI

This report contributes to the analysis of the **key pillars put forward in the 'Blueprint for the development of transition pathways'**[3] of the Industrial Forum developed in 2022.

The updated EU Industrial Strategy[4] underlines a swift green and digital transition of EU industry and its ecosystems. As a result, each industrial ecosystem must transform its business models and value chains in support of a green, digital, and resilient European economy. The concrete and actionable plans to enable this transition are outlined in the **Transition Pathway for the agri-food industrial ecosystem**[5]. The Transition Pathway is developed based on the Staff Working Document (SWD)[6] on the co-creation of the transition pathway, a public consultation[7] and workshops with key stakeholders.

[3] European Commission (2022) Blueprint for the development of transition pathways for industrial ecosystems. Retrieved from: https://ec.europa.eu/docsroom/documents/49407/attachments/1/translations/en/renditions/native

[4] EUR-Lex (2021) Communication from The Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of The Regions. Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021DC0350

[5] European Commission (2024) Transition pathway for the agri-food industrial ecosystem. Retrieved from: a2d02a42-b7d4-4dfd-affb-0d9510dd405c_en (europa.eu)

[6] European Commission (2023) Commission Staff Working Document – Co-creation of a transition pathway for a more resilient, sustainable and digital agri-food ecosystem. Retrieved from: https://ec.europa.eu/docsroom/documents/55334

[7] European Commission. Consultation. Retrieved from: Transition pathway for a more resilient, sustainable and digital agri-food ecosystem

Furthermore, this report considers and builds upon other European Commission strategies, such as the Farm to Fork strategy[8], initiatives and reports or data sources, such as the Common Agricultural Policy (CAP) indicators[9]. Data and information from other European and international agencies and organisations, such as the UN Environmental Programme, the Food and Agriculture Organisation of the United Nations (FAO), and the OECD, were also consulted.

A key input to the report has also been a stakeholder workshop held on 13 September 2024[10], along with follow-up exchanges with stakeholders whose relevant insights are reflected in the report. Insights from the workshop were used to refine especially the technology lists related to both the green and digital transition as well as the interpretation of results.

1.2. Scoping the agri-food industrial ecosystem

Agri-food typically refers to both agriculture & farming (NACE A, excluding A2) and food processing activities (NACE C10-12). For this study, we focus on the agri-food industrial ecosystem as it is outlined in the Industrial Strategy[11], Annual Single Market Report[12] and the transition pathway[13].

According to the transition pathway of the **agri-food industrial ecosystem**, the industrial ecosystem covers all operators in the food supply chain including farmers, fishers, aquaculture producers, the food and drink industry, food retail and wholesale, and food service. It also encompasses suppliers of inputs and services (seeds, pesticides, fertilisers, machinery, packaging, repair, transport, finance, advice, and logistics).

Practically following this definition, this report focuses on **activities in agriculture and farming, and food and beverages**. In doing so, the following activities are excluded:

- Forestry & logging
- Cannabis
- Equestrian
- Transportation related to food delivery and logistics
- Industrial equipment and machinery related to agri-food
- Chemicals, especially pesticides, fertiliser and other agricultural chemicals
- Hunting & trapping
- Cooking and recipes

The data reported adhere — to the extent possible — to this ecosystem delineation. Where there are differences in terminology, the term related to the underlying source of information is applied (i.e. food system, agriculture, among others). The methodological

[8] European Commission (n.d.) Farm to Fork strategy. Retrieved from: https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en

[9] European Commission (n.d.) CAP indicators. Retrieved from: https://agridata.ec.europa.eu/extensions/DataPortal/cap_indicators.html

[10] The "Workshop on monitoring the green and digital transition of the agri-food industrial ecosystem", held on September 13, 2024 from 10.00 to 12.00 CET, included a presentation of the preliminary results of the analysis of the agri-food industrial ecosystem under EMI by the study team, followed by an in-depth discussion with relevant stakeholders on the analysis to refine, validate, and further interpret the findings. Participants included policymakers, representatives from industry associations, innovation actors and researchers.

[11] European Commission (n.d.) European Industrial Strategy https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-industrial-strategy_en

[12] European Commission (2021) Annual Single Market Report 2021. Retrieved from: https://commission.europa.eu/system/files/2021-05/swd-annual-single-market-report-2021_en.pdf

[13] European Commission (2024) Transition pathway for the agri-food industrial ecosystem. Retrieved from: https://single-market-economy.ec.europa.eu/document/download/a2d02a42-b7d4-4dfd-affb-0d9510dd405c_en?filename=Transition%20Pathway%20for%20the%20agri-food%20industrial%20ecosystem%20-%20final_en.pdf

report[14] includes details on the NACE sectors and information on the coverage of each industrial ecosystem by data source. Nevertheless, the methods and industrial ecosystem coverage by data source are briefly described in the related chapters below.

The agri-food industrial ecosystem is outlined by a series of key characteristics and traits which also showcase its positioning in the wider landscape. According to the 2024 edition of the Eurostat Key figures in the European food chain report, the total value added of the agriculture, food and beverage processing, food and beverage wholesaling and retailing and food and beverage serving activities amounts to EUR 991.2 bn based on figures from 2022[15]. Small and Medium Enterprises (**SMEs**) are the backbone of the agri-food industrial ecosystem, reaching 99% of total business' and comprising almost half of the industrial ecosystem's turnover and employment[16].

Looking at the industries that relate to the industrial ecosystem, notably the EU food and beverage industry employed 4.6 million people, while generating a turnover of EUR 1.1 trillion and a value added of EUR 229 bn in 2023, making it one of the largest manufacturing industries in the EU[17].

The agriculture and farming industry specifically produced a total output value of EUR 427 bn, with 50% of this value coming from crops, 40% from livestock and the remainder from secondary activities[18]. The share of agriculture in overall employment is 4%, representing 20.5 million full and part-time jobs[19].

In global comparison, the food and agribusiness industry accounts for 35% of all jobs in the world and 10% of global GDP according to a 2023 study by Bain & Company and the World Economic Forum[20].

The total production value for the agri-food industrial ecosystem gives insight into the production performance of the ecosystem.

Figure 2 shows a **continuous growth in the production value** over the considered period of 2012-2023, highlighting the increasing importance of agriculture and food for internal consumption and exports. Data on production were extracted from the PRODCOM dataset of Eurostat[21]. PRODCOM statistics reveal the total values of production of manufactured goods conducted by enterprises located in EU27[22].

---

[14] Available at: https://monitor-industrial-ecosystems.ec.europa.eu/about/monitoring-framework

[15] Eurostat (2024). Key figures on the European food chain – 2024 edition. Retrieved from: https://ec.europa.eu/eurostat/web/products-key-figures/w/ks-01-24-000

[16] European Commission (2024) Agri-food industrial ecosystem. Retrieved from: https://data.europa.eu/doi/10.2873/427449

[17] FoodDrink Europe (2023) Data & Trends of the European Food and Drink Industry 2023. Retrieved from: https://www.fooddrinkeurope.eu/resource/data-trends-of-the-european-food-and-drink-industry-2023/

[18] Copa Cogeca (n.d.) European Farming. Retrieved from: https://www.copa-cogeca.eu/europeanfarming

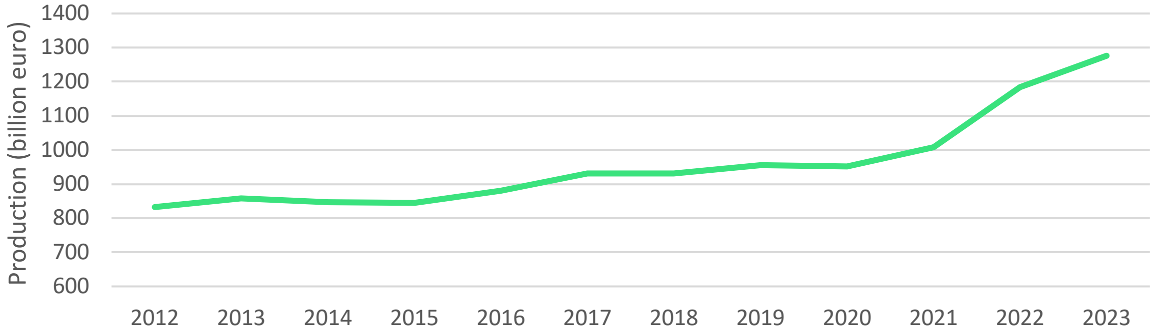
[19] Copa Cogeca.(n.d.) European Farming. Retrieved from: https://www.copa-cogeca.eu/europeanfarming

[20] World Economic Forum; Bain & Company (2023) Food, Nature and Health Transitions – Repeatable Country Models.

[21] Eurostat (2023) Industrial production statistics introduced – PRODCOM. Retrieved from: https://www.bain.com/globalassets/early_movers_food_system_transformation.pdf

[22] The agri-food industrial ecosystem is delineated by the NACE 2 classification based on weights identified in the Annual Single Market Report . The data presents the weighted sum of production of manufactured goods aggregated at NACE 2-digit level for the agri-food industrial ecosystem (in bn EUR).

Figure 2: Evolution of the production value in the agri-food industrial ecosystem



Source: IDEA Consult based on Eurostat (prom)

The year 2019-2020 showed lower growth rates, which can be associated with the COVID-19 pandemic. From 2020 onwards, however, a strong resurge can be observed. This increasing trend goes hand in hand with the soaring food prices and inflation in 2021, especially in 2022 and 2023[23] due to the increase in costs of raw materials and energy.

While relatively robust and stable in the EU, the agri-food industrial ecosystem is experiencing several **structural issues** and has recently been exposed to multiple shocks, affecting environmental, social and economic sustainability and resilience.

The ecosystem has been historically known for its global **environmental impact**. For instance, deforestation and biodiversity loss, soil degradation and water pollution have adverse effects on the environment. At the global level, the share of emissions from the agri-food industrial ecosystem relative to total emissions across all sectors dropped from 38 percent in 2000 to 31 percent in 2020, primarily due to faster growth in non-food emissions.[24]. At the same time, **climate change** also has a considerable impact on the food system and is changing crop yields[25]. This affects, amongst others, the viability of rural areas and influences food security and sustainable and healthy diets.

Farmers and fishers typically have **lower incomes** than other economic sectors and have limited market influence due to **power imbalances** in the food chain. They also face uncertainties from climate risks (e.g., droughts, floods, heat waves), price volatility, and dependency on fossil fuels[26].

The agri-food industrial ecosystem faces **low generational renewal**, as fewer young people are drawn to careers in the agri-food industrial ecosystem. Only 5.6% of all European farms are run by farmers younger than 35 years of age, while more than 31% of all farmers are older than 65[27]. Finding a **skilled workforce** and upskilling are increasingly challenging, even for large food companies.

Agri-food SMEs and farms need more investment for green and digital transitions, as **R&D investments** in food are considered low compared to other sectors[28].

---

[23] Eurostat (2023) EU food prices: olive oil up 75% since January 2021. Eurostat. 2023. Retrieved from: https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20231102-1

[24] FAO (2022) Greenhouse gas emissions from agrifood systems. Retrieved from: https://openknowledge.fao.org/server/api/core/bitstreams/121cc613-3d0f-431c-b083-cc2031dd8826/content#:~:text=In%202020%2C%20global%20annual%20anthropogenic,percent%20higher%20than%20in%202000

[25] European Commission (2024) Agri-food industrial ecosystem. Retrieved from: https://data.europa.eu/doi/10.2873/427449

[26] European Commission (2023) Co-creation of a transition pathway for a more resilient, sustainable and digital agri-food ecosystem. Retrieved from: https://ec.europa.eu/docsroom/documents/55334

[27] Copa Cogeca. European Farming in figures. Retrieved from: https://www.copa-cogeca.eu/europeanfarming#b188

[28] European Commission (2023) Co-creation of a transition pathway for a more resilient, sustainable and digital agri-food ecosystem. Co-creation of a transition pathway for a more resilient, sustainable and digital agri-food ecosystem. Retrieved from: https://ec.europa.eu/docsroom/documents/55334

Furthermore, the agri-food industrial ecosystem has been affected by **large increases in input costs,** especially energy and volatility of raw material prices. The agri-food industrial ecosystem also must adapt to new consumer trends amid low margins[29].

[29] European Commission (2023) Co-creation of a transition pathway for a more resilient, sustainable and digital agri-food ecosystem. Co-creation of a transition pathway for a more resilient, sustainable and digital agri-food ecosystem. Retrieved from: https://ec.europa.eu/docsroom/documents/55334

2. Green transition

2.1. Industry efforts to green the industrial value chain

What progress has the industry made in taking action for the environment?

- The number of patent applications in the agri-food industrial ecosystem **tends to be lower** compared to other ecosystems. Consequently, patents are typically concentrated in specific technological fields such as **biotechnology**.

- In 2024, **32% of companies in the agri-food industrial ecosystem have adopted strategies for climate neutrality**, showing a modest commitment.

- Agri-food companies have been actively implementing measures to **enhance material conservation** with **good progress from 2021 to 2024,** increasing from 58% to nearly 70%. This was followed closely by energy-saving initiatives, adopted by 65% of companies, and waste minimisation efforts, embraced by 62% of companies in 2024. Additionally, 49% of agri-food companies focused on conserving water within their operations. These measures highlight the industry's prioritisation of resource efficiency as part of its green transition efforts. The shift from minimising waste to saving materials highlights the importance of circular thinking in the agri-food industrial ecosystem and a shift along this mentality.

- Environmental startups in agri-food are led by business models in the areas of **healthy food** and **alternative proteins,** with 297 and 244 startups created in these areas, respectively over the period 2015-2022. In addition, startups also focus on biotechnology and renewable energy in the agri-food industrial ecosystem.

- Investments in resource efficiency are not prioritised by 29% of agri-food companies, while 46% of companies invest less than 5% of annual revenue in resource efficiency. The majority of companies invest less than 1% or between 1 and 5% of annual turnover in environmental technologies and measures (56%). These results suggest that own financial resources in agri-food will not be enough to finance green transformation of the agri-food industrial ecosystem.

- **Venture capital investments** lie predominantly in the area of **alternative proteins** over the period 2015-2023, highlighting the relative importance of alternative proteins as a topic for young companies.

This section reports first on the progress of firms within the industrial ecosystem towards the green transition, focusing on the adoption of environmental technologies and circular business models. It also analyses how startups and young companies that provide environmental solutions in agri-food contribute to the transformation of the industrial value chain. Moreover, it examines the level of investment by agri-food companies in the green transition including green technologies, renewable energy, and circular economy solutions across the agri-food industrial ecosystem encompassing activities in agriculture and farming, and food and beverages.

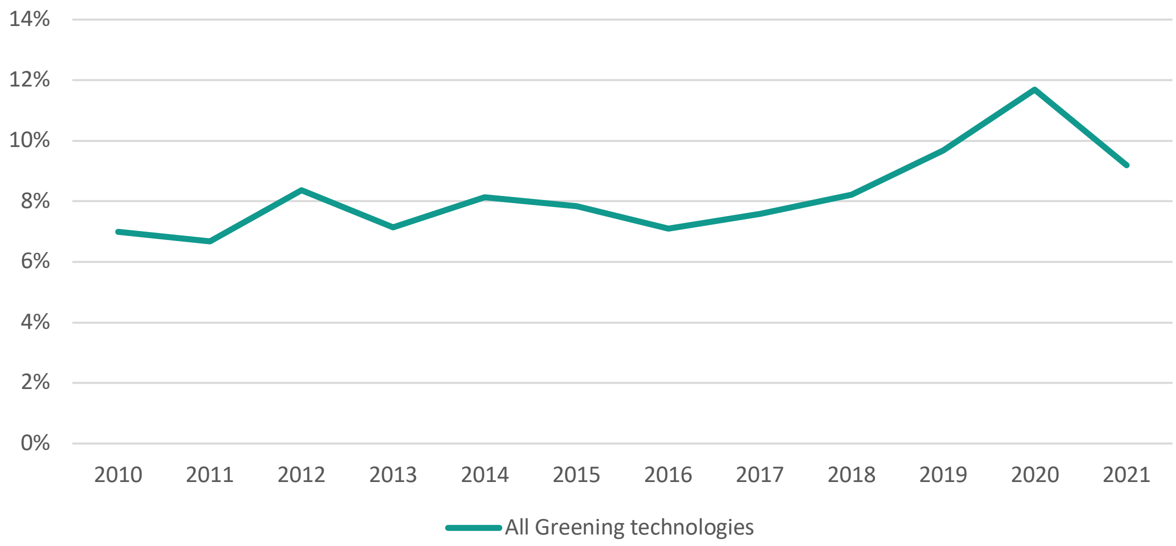
2.1.1. Technology generation

In the agri-food industrial ecosystem, the number of patent applications tends to be lower compared to other ecosystems. Consequently, patents are typically concentrated in specific technological fields such as biotechnology. This can be attributed to many companies choosing to protect their innovations through trade secrets, recipes, and know-how instead of seeking patent protection.

Technology development in agri-food has been captured based on the patenting activities related to the specific sectoral activities. The analysis is based on 'transnational patents' (Frietsch/Schmoch, 2010)[30] and was conducted on an extended version of the EPO's Worldwide Patent Statistical Database that Fraunhofer ISI implemented locally. Technologies-relevant-to-ecosystems, in this case the agri-food industrial ecosystem, are defined based on a search that refers to patent classifications[31]) and/or use keywords to identify relevant applications across classes.

Looking at the technologies related to the green transition[32] as presented in the methodological framework, the Figure below presents the share of all greening patents in all patents filed for the agri-food industrial ecosystem among the EU27 industrial ecosystems overall. The resulting patent shares presented in Figure 3 of between roughly 7% and 12% are generally well aligned with the insights obtained during a focus group held by FoodDrinkEurope in 2023. The focus group found that only 10% of R&I undertaken by companies in the food industry is patented[33]. A remarkable increase in the year of the COVID-19 pandemic is evident, showcasing the relative importance of creating new innovations during the pandemic.

Figure 3: Share of greening patents in all patents filed for the agri-food industrial ecosystem among the EU27 industrial ecosystems overall



Source: Fraunhofer based on PATSTAT

At the level of green technologies, advanced materials such as specific additives, clean production technologies and biotechnology are the three leading technologies according to patenting activities for the agri-food industrial ecosystems over the period 2010 to 2021 (see Figure 4). Recent years show the increasing importance of advanced materials, clean production technologies, circular economy and biotechnology in 2019 and 2020, however followed by a sharp decline in 2021 especially for clean production technologies and advanced materials and nanotechnology

Figure 4: Share of respective green transition technologies in overall patents filed in agri-food industrial ecosystem

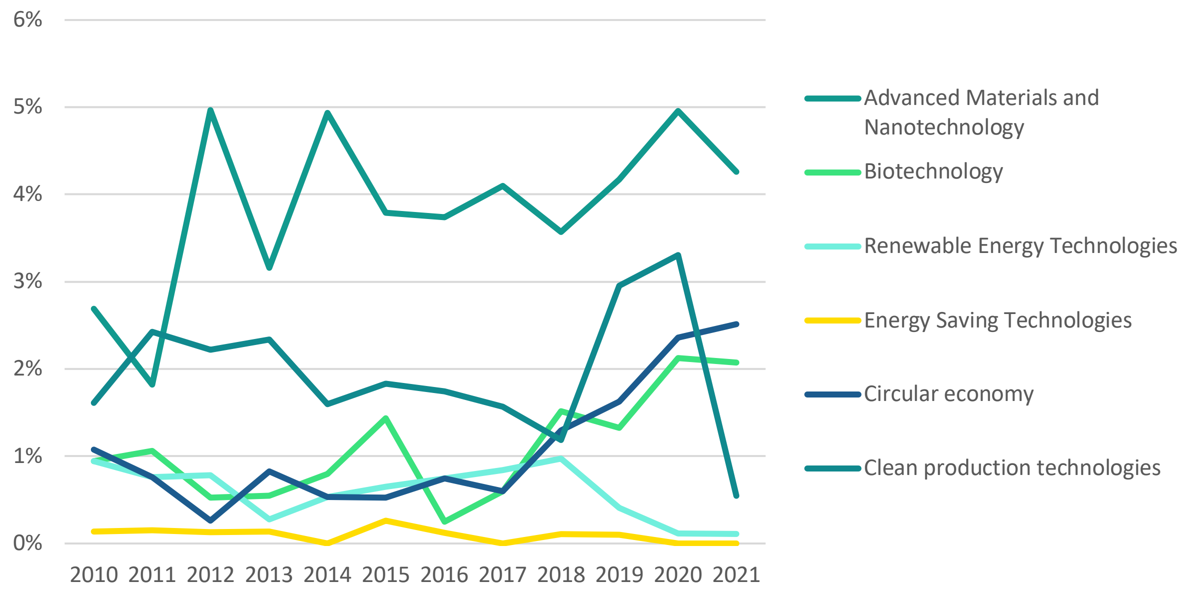
[30] i.e. PCT/WIPO filings or direct applications at the EPO, excluding double counts

[31] Relying on the International Patent Classification (IPC)

[32] Green transition technologies: advanced materials, biotechnology, clean production technologies, energy saving technologies, recycling technologies, renewable energy

[33] European Commission (2023) Food Systems. Research and innovation investment gap study: policy report. Retrieved from: https://op.europa.eu/en/publication-detail/-/publication/1747dc15-be80-11ed-891213 01aa75ed71a1

☐



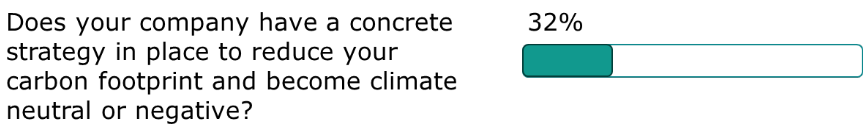
Source: Fraunhofer based on PATSTAT

2.1.2. Uptake of green technologies and circular business models

The adoption of technologies and circular business models in the agri-food industrial ecosystem has been investigated in detail by the Eurobarometer 2024[34] and has been complemented by a large-scale CATI[35] survey conducted as part of the EMI project over the period from July-September 2024 with a sample of 706 companies from the agri-food industrial ecosystem. As the following sections will show, despite the industry's significant environmental impact, it has **made progress towards the green transition, particularly in the areas of material and energy conservation**. However, the **ecosystem still faces challenges in other key areas, such as water conservation and the adoption of circular business models**. These gaps indicate that while progress has been made, further efforts are necessary to fully align the industry with green transition goals.

According to the Eurobarometer 2024 survey results, 32% of companies have a concrete strategy to reduce carbon footprint or become climate neutral or negative.

Figure 5: Share of companies in agri-food industrial ecosystem that has adopted strategy to reduce carbon footprint.



Source: Eurobarometer survey 2024

As shown in Figure 6, in 2024, the most widely adopted environmental measure among agri-food companies was material conservation, implemented by 69% of respondents. This was followed closely by energy-saving initiatives, adopted by 65% of companies, and waste minimisation efforts, embraced by 62%. Additionally, 49% of agri-food companies focused on conserving water within their operations. These measures highlight the industry's prioritisation of resource efficiency as part of its green transition efforts. Comparably, in 2021, the priority environmental measures that were adopted by firms were dominated by

[34] Eurobarometer 2024. Available at: https://europa.eu/eurobarometer/surveys/detail/3215
[35] Computer-Assisted Telephone Interviewing

minimising waste (73%), followed by saving energy (60%), and saving materials and water (both 58%). The shift from minimising waste to saving materials highlights the importance of circular thinking in the agri-food industrial ecosystem and a shift along this mentality. The increased importance of saving energy can also be attributed to the energy crisis and associated impacts on energy prices forcing firms to prioritise these actions to better manage rising costs.

Figure 6: Share of firms indicating the adoption of environmental measures

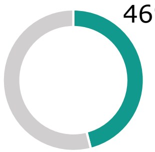
Environmental measures	***Share of adoption (2021)***	***Share of adoption (2024)***
Saving materials	58%	69.4% ↑
Saving energy	60%	65.3% ↑
Minimising waste	73%	61.7%
Saving water	58%	48.9%
Recycling, by reusing material or waste within the company	48%	42.9%
Switching to greener suppliers of materials	39%	35.8%
Selling your residues and waste to another company	44%	28.7%
Using predominantly renewable energy	27%	20.1%
Designing products that are easier to maintain, repair or reuse	41%	18.8%

Source: Eurobarometer survey 2024

As a result of these actions, 28% of the companies observed decreased production costs, while for 50% of the companies, the production costs increased. This suggests that for nearly half of the agri-food companies, the transition to greener practices may initially involve higher investments or operating costs, which could challenge their competitiveness, at least in the short term. However, the long-term effects could still offer potential competitive advantages, compliance with regulations, and alignment with consumer preferences for sustainability[36]. Consequently, within the next two years, saving energy, minimising waste, saving materials, saving water and recycling are areas where more than 40% of agri-food companies are planning to dedicate additional efforts[37].

To further contribute to the green transition, a large share, notably 46% of the companies surveyed in agri-food indicated that they have relied on environmental services provided by third-party providers (as illustrated in the Figure below).

Figure 7: Purchasing environmental services



46%

of Agri-Food companies bought any environmental services over the past five years from third parties such as energy audit, carbon footprint analysis, water audit

Source: EMI Enterprise Survey 2024, n=706

[36] For example, Hermundsdottir, F., & Aspelund, A. (2021). Sustainability innovations and firm competitiveness: A review. Journal of Cleaner Production, 280, 124715.
[37] Eurobarometer survey, 2024

In addition to implementing measures focused on enhancing resource efficiency and promoting climate neutrality, agri-food enterprises have taken a more direct approach by installing specific green technologies.

The efforts of companies within the agri-food industrial ecosystem to advance the green transition are concentrated on several key technological areas. These areas build on the technologies outlined in the methodological framework, while also allowing for interpretation specific to the unique needs and challenges of the agri-food industrial ecosystem. These technological focuses aim to drive sustainability, reduce environmental impact, and enhance the overall efficiency of the ecosystem. These include:

- Biotechnology
- Recycling technologies
- Renewable energy technologies
- Alternative protein
- Healthy food

Although the green and digital transition of the agri-food industrial ecosystem are intertwined, this report sets out to explore the transition and technological developments thereunder independently.

According to the EMI survey 2024, **53% of agri-food companies have invested in energy-saving technologies, marking a significant increase compared to the previous year.** This upward trend reflects a growing commitment to energy efficiency and indicates that more businesses in the ecosystem are actively pursuing strategies to reduce energy consumption and lower their environmental impact.

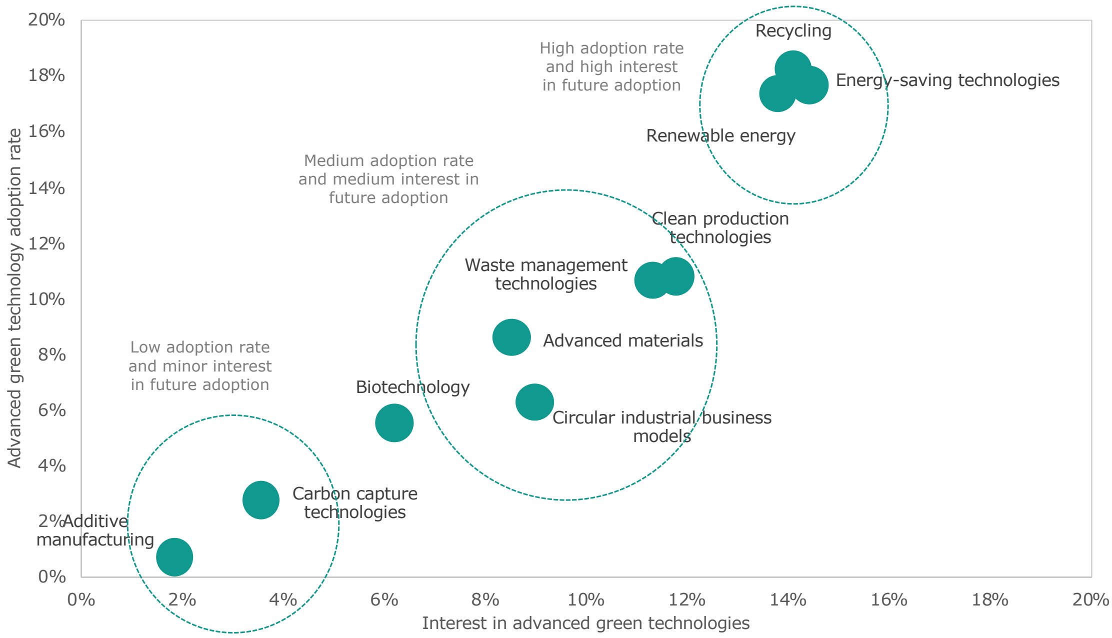
Figure 8: Adoption of green technologies and circular economy models by companies in agri-food

Green technologies	***Share of adoption (2023)***	***Share of adoption (2024)***
Energy-saving technologies	33%	52.92%
Waste management technologies	27%	33.07%
Clean production technologies	28%	31.13%
Advanced materials	27%	26.07%
Biotechnology	20%	21.00%
Circular industrial business models	19%	19.07%

Source: EMI Enteprise survey 2024, n=706

The survey data cross analysis indicates that the current adoption rate of recycling, energy saving and renewable energy technologies is relatively higher than of other green technologies (approximately between 17% and 18%). Secondly, the same technologies have the highest interest among surveyed companies to be implemented in the future.

Figure 9: Green technology adoption and technology generation in agri-food industrial ecosystem



Source: EMI Enterprise Survey 2024

Note: Advanced green technology adoption rate is based on the responses to survey question "Which environmental technologies and measures has your company adopted or implemented?" Interest in advanced green technologies is based on the responses to survey question "Which environmental technologies and measures is your company planning to adopt or implement?"

Biotechnology

As defined by the OECD, biotechnology applies science and technology to living organisms, as well as parts, products and models of them, to alter living or non-living materials to produce knowledge, goods and services[38]. Biotechnology supports a greener and more productive agriculture, by relying on natural means to increase plant defences or increase crop yield[39]. It includes a wide range of applications, such as fermentation and brewing, which have been around for millennia, but also genetically modified organisms (GMOs) or new genomic techniques (NGTs)[40]. Biotechnology brings about many advantages that are changing the agri-food industrial ecosystems, such as the creation of functional foods that offer additional health benefits (biofortification), new methods of preservation (e.g., through the use of enzymes and microorganisms), and alternative food production (e.g., lab-grown meat)[41].

A recent JRC report[42] on biotechnology indicates that looking at biotechnology patents in all sectors, there are relatively limited patents in green biotechnology. Most patents are in red (medical biotechnology) and white biotechnology (industrial biotechnology). In addition, the report shows that especially Chinese patent applicants are relatively specialised in green biotechnology, and UK applicants are least specified in green

38 European Commission (n.d.) Biotechnology. Retrieved from: https://single-market-economy.ec.europa.eu/sectors/biotechnology_en

39 European Commission (n.d.) Biotechnology. Retrieved from: https://single-market-economy.ec.europa.eu/sectors/biotechnology_en

40 FAO (n.d.). What is agricultural biotechnology? Retrieved from: https://www.fao.org/4/y5160e/y5160e07.htm

41 Food 4 Future – Expo FoodTech (2024) Biotechnology and Food: A glimpse into the future of the food industry. Retrieved from: https://www.expofoodtech.com/biotechnology-food-glimpse-future-food-industry/

42 Grassano, N., Napolitano, L., M`barek, R., Rodriguez Cerezo, E. and Lasarte Lopez, J., Exploring the global landscape of biotech Innovation: preliminary insights from patent analysis, Publications Office of the European Union, Luxembourg, 2024, doi:10.2760/567451, JRC137266.

biotechnology. The EU applicants are relatively most specialised in white biotechnology patents.

The European Commission is currently focusing attention to boost biotechnology and biomanufacturing in the EU as they have identified it as one of the most promising technological areas of the century[43]. In particular, the Commission is putting forward actions to, amongst others, leverage research, stimulate market demand, foster public and private investments, and streamline regulatory pathways. In the context of the latter, a study is carried out to lay the foundations for a possible EU Biotech Act.

The EMI survey 2024 found that 21% of agri-food companies adopted this technology.

Recycling technologies

A recycling technology refers to a specific combination of physical or chemical concepts, principles, and practices to recycle a waste stream of a certain type and collected in a certain way[44]. The focus is placed very much on the aspect of materials. In the agri-food industrial ecosystem, this refers to both the agri-food product and its eventual recycling, valorisation or that of its production bi-products/waste, as well as the packaging that is utilised for the product.

The Transition Pathway of the agri-food industrial ecosystem underlines the importance of developing advanced **sorting and recycling technologies.**[45]. While the majority of recycling of food packing is still based on mechanical recycling with only 40% of food packing being recycled overall[46], a shift towards **chemical recycling**, presents a novel, forthcoming opportunity to support the transition towards more circular packaging. In general, **chemical recycling** is the process of converting polymeric waste by altering its chemical structure, transforming it back into substances that can serve as raw materials for manufacturing plastics or other products. As chemical recycling breaks down polymers into their building blocks, it allows the production of recycled plastic with **virgin plastic properties** that can be used in demanding applications, such as food contact. As a result, it can be used for plastic waste which would otherwise result in incineration or landfill. Various chemical recycling technologies exist, including pyrolysis, gasification, hydro-cracking, and depolymerisation[47].

The Eurobarometer found that 42.9% of agri-food companies took measures in the field of recycling in 2024, a lower share than in 2021.

The EU Packaging and Packaging Waste Regulation (PPWR) puts forward new rules to support in further reducing waste and encouraging re-use in the EU, notably targeting safe, sustainable and recyclable packaging with minimum percentages of recycled content, minimised weight and volume of packaging and minimising substances of concern[48].

Note that elements related to smart and sustainable packaging are discussed in the chapter on the demand for digital services by consumers, as well as the retail industrial ecosystem report.

Renewable energy technologies

---

[43] European Commission (2024). Press release. Commission takes action to boost biotechnology and biomanufacturing in the EU. https://ec.europa.eu/commission/presscorner/detail/en/ip_24_1570

[44] European Commission (n.d.) Plastic Recycling. Retrieved from: https://food.ec.europa.eu/safety/chemical-safety/food-contact-materials/plastic-recycling_en

[45] European Commission (2024) Transition pathway for the agri-food industrial ecosystem. Retrieved from: https://single-market-economy.ec.europa.eu/document/download/a2d02a42-b7d4-4dfd-affb-0d9510dd405c_en?filename=Transition%20Pathway%20for%20the%20agri-food%20industrial%20ecosystem%20-%20final_en.pdf

[46] Food packaging Forum (2024) European industry associations report latest recycling rates. Retrieved from: https://foodpackagingforum.org/news/european-industry-associations-report-latest-recycling-rates

[47] Plastics Europe (n.d.) Chemical recycling. Retrieved from: https://plasticseurope.org/sustainability/circularity/recycling/chemical-recycling/

[48] European Council (2024). Sustainable packaging: Council signs off on new rules for less waste and more re-user in the EU. Retrieved from: https://www.consilium.europa.eu/en/press/press-releases/2024/12/16/sustainable-packaging-council-signs-off-on-new-rules-for-less-waste-and-more-re-use-in-the-eu/

The Transition Pathway of the agri-food industrial ecosystem underlines that for the sustainability transition in agri-food, amongst others, a switch to renewable energy in agri-food will be needed[49]. This plays a role in meeting the needs for electricity, heating, cooling and transport needs of the food system. For example, renewable energy technologies to transform waste to energy are particularly important to ensure energy security and overall resource efficiency. Various renewable energy applications are being deployed in the agri-food industrial ecosystem including:

- **Sustainable bioenergy** is a renewable energy source crucial for electricity, heat, and transport fuels within the agri-food industrial ecosystem and beyond. Biomass by-products from agri-food activities can produce energy for processing and storage. Crop and livestock residues, can generate bioenergy, manure and processed materials from agriculture, and produce biogas for different uses. Biogas power plants operate in various sectors like sugar, slaughterhouses, and food processing generally[50].
- **Solar irrigation,** which is among the most mature renewable energy technologies globally and is adopted to improve access to water, thus enabling multiple cropping cycles and increasing resilience[51].
- **Renewables-based agro-processing systems** present a cost-effective alternative to fossil fuels. These include systems that rely on renewable energies to power certain processing stages of the value chain. Examples include solar-powered grain milling, mini grids for post-harvest processes including oil-pressing, as well as geothermal power for factories. They reduce environmental impact, promote decentralised processing infrastructure, and lessen labour-intensive activities. Despite their high potential across various value chains, the adoption of renewables in agro-processing is still in its early stages[52].

Clean production technologies

In the context of the agri-food industrial ecosystem, clean production technologies as also outlined in the EMI methodological report[53] are relevant to support the green transition of both the agricultural and food processing activities of the ecosystem. The notion includes aspects related to technologies that support limiting industrial emissions, as well as addressing other areas of environmental impact such as reduction of biodiversity loss, reduction of food waste and food loss during production, water management systems, or sustainable soil tillage approaches[54]. Alternative production techniques such as urban agriculture and vertical farming are also included.

The EMI Survey 2024 revealed that 31% of businesses in the agri-food industrial ecosystem adopted clean production technologies in 2024, marking an increase compared to 2023. This growth highlights the rising importance of advanced technologies in enhancing sustainability and innovation within the ecosystem.

Circular business models

Furthermore, novel business models have emerged within the agri-food industrial ecosystem in recent years, which have been adopted at various levels by both the industry and consumers[55].

---

[49] European Commission (2024) Transition pathway for the agri-food industrial ecosystem.
[50] European Commission (2021) Renewable Energy and Agri-food Systems: Advancing Energy and Food Security towards Sustainable Development Goals. Retrieved from: https://knowledge4policy.ec.europa.eu/publication/renewable-energy-agri-food-systems-advancing-energy-food-security-towards-sustainable_en
[51] IRENA & FAO (2021) Renewable energy for agri-food systems – Towards the Sustainable Development Goals and the Paris agreement. Abu Dhabi and Rome. Retrieved from: https://doi.org/10.4060/cb7433en
[52] IRENA & FAO (2021) Renewable energy for agri-food systems – Towards the Sustainable Development Goals and the Paris agreement. Abu Dhabi and Rome. Retrieved from: https://doi.org/10.4060/cb7433en
[53] https://monitor-industrial-ecosystems.ec.europa.eu/about/monitoring-framework
[54] see also https://monitor-industrial-ecosystems.ec.europa.eu/technologies/clean-production-technologies
[55] See also https://monitor-industrial-ecosystems.ec.europa.eu/technologies/circular-business-models

Alternative proteins

Alternative proteins, such as those from plants, algae, insects, and ingredients produced with the help of cellular agriculture make an important contribution toward protein diversification as products or ingredients for food and feed. Protein diversification, substituting animal proteins with alternative proteins, is widely regarded as one of the most effective investments in reducing the climate impact of the food system. In 2023, protein diversification reached a pivotal moment, gaining prominence on political agendas and influencing regulatory frameworks globally. For instance, Denmark introduced its inaugural national action plan to promote a shift towards plant-based foods, while France and the Netherlands allocated substantial research and innovation funds to support this transition. Yet, also in early 2023, Italy proposed a ban on cultivated meat products with a view to protect traditional livelihoods and cultural heritage[56]. Furthermore in 2023, the FAO published robust scientific evidence on the safety of cultivated meat in its inaugural report on cell-based food safety[57].

In general, the trends in the uptake of alternative proteins look promising, within Europe, retail sales of meat and dairy alternatives having increased by almost 10% per year between 2010 and 2020, and several supermarket chains have reported an annual growth rate of nearly 100% for protein alternatives to meat[58]. As a result, the market for alternative protein products is projected to grow exponentially to a value of at least EUR 264 bn[59] by 2035. It is estimated that by 2035, between 11% and 22% of global meat, seafood, eggs and dairy consumption will be replaced by alternative proteins[60].

Healthy food

Obesity and overweight rates have reached epidemic levels in Europe, affecting nearly 60% of adults and one-third of children in the world, as reported by the WHO European Regional Obesity Report 2022[61] resulting in the rise of Noncommunicable diseases including cardiovascular disease and diabetes[62]. In addition, in the European Union, about 60 percent of consumers actively tried to eat healthy in 2023[63]. Addressing these challenges require reducing dietary inequalities and creating a healthier, more equitable food system. However, no single intervention can stop the obesity epidemic; instead, multiple levels of intervention are necessary. Selected approaches and business models related to reformulation aim at ensuring that ingredients in food products are low in fat, salt and sugar.

In addition, organic food, or even regenerative agriculture[64] emphasise the health benefits of less pesticide use as compared to conventional approaches, even seeks to have more nutritious food as a result of more sustainable farming practices.

Targeted or personalised nutrition, tailored to individual characteristics and behaviours, is crucial for reducing malnutrition, obesity, and related diseases, and has been identified by EIT Food as a key focus area[65].

---

[56] EIT Food (2023) Protein Diversification Think Tank Policy Brief on Accelerating Protein Diversification for Europe. Retrieved from: https://www.eitfood.eu/reports/protein-diversification-think-tank-policy-brief

[57] FAO & WHO (2023).Food safety aspects of cell-based food. Rome. Retrieved from: https://doi.org/10.4060/cc4855en

[58] EIT Food (2022) Protein Diversification. Retrieved from: https://www.eitfood.eu/files/EIT-FOOD-WHITE-PAPER-PROTEIN-DIVERSITICATION-2022_FINAL15-12-22.pdf

[59] All currencies are based on current exchange rate of 1EUR = $US 1.09724, 8 October 2024

[60] EIT Food (2022) Protein diversification. Retrieved from: https://www.eitfood.eu/files/EIT-FOOD-WHITE-PAPER-PROTEIN-DIVERSITICATION-2022_FINAL15-12-22.pdf

[61] World Health Organization (2022) WHO European Regional Obesity Report 2022. Retrieved from: https://iris.who.int/bitstream/handle/10665/353747/9789289057738-eng.pdf?sequence=1

[62] World Health Organisation (2024) Noncommunicable diseases. Retrieved from: https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases

[63] Statista (2023) Consumers' attitudes towards food in the European Union 27 in 2023. Retrieved from: https://www.statista.com/statistics/1447744/attitudes-towards-food-in-the-eu-27/

[64] EIT Food Blogpost (2023) Does regenerative agriculture produce healthier food? Retrieved from: https://www.eitfood.eu/blog/does-regenerative-agriculture-produce-healthier-food

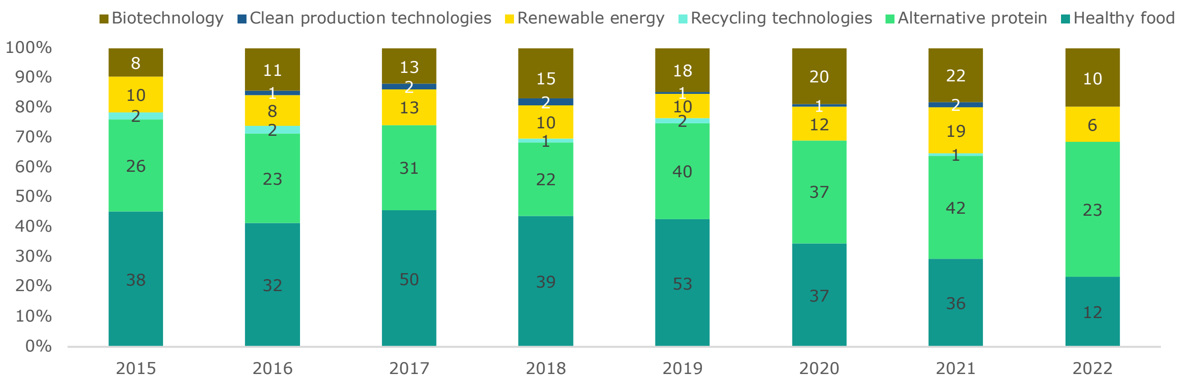
[65] EIT Food (2022) Targeted nutrition: innovation to reduce dietary inequalities. Retrieved from: https://www.eitfood.eu/blog/targeted-nutrition-innovation-to-reduce-dietary-inequalities

2.1.3. Environmental startups in agri-food

Capturing information on startup creation allows to give insight into the novel technologies being generated related to the agri-food industrial ecosystem. The analysis of startup generation has been compiled through a database encompassing Crunchbase and Net Zero Insights[66] data.

A total of **735 agri-food startups were created in support of the green transition** between **2015 and 2022**. A look at the level of the green transition related technologies as presented in Figure 10 reveals which technologies are leading in startup creation. Notably, healthy food as described in the technologies above, stands out with a total of 297 startups identified over the indicated period as is such the leading business model, followed closely by alternative proteins with 244 startups created over the indicated period. Biotechnology is the third most important technology for startup creation, with a total of 117 startups founded related to this technology in the period of 2015 to 2022. Renewable energy remains an important technology as well with a total of 88 startups in this area for the same period. Both clean production technologies and recycling technologies report notably lower figures in this regard, with between zero and two startups created per year. This can be attributed to the relative association of these technologies to other industrial ecosystem domains, with recycling technologies relevant in the domain of retail, especially related to packaging.

Figure 10: Breakdown by green technology and circular business model in the agri-food industrial ecosystem



Source: Technopolis Group based on Crunchbase and Net Zero Insights

Several programmes exist at European level to support and identify emerging startups in the agri-food industrial ecosystem such as the RisingFoodStars programme[67] of EIT Food, as well as EIT Food's initiative to identify start-ups to watch[68] as well as the EIT specific challenges[69].

Examples of startups include:

- **InnovaFeed[70]** (alternative protein) is a biotechnology company founded in 2016 that produces insect-based protein for the feed industry.
- **Umiami[71]** (alternative protein) founded in 2020, is a French food-tech startup that develops plant-based food technology to reduce meat consumption focussing on plant-based meat and fish for the food industry.

[66] www.crunchbase.com and https://netzeroinsights.com/
[67] EIT (n.d.) SCALE – RisingFoodStars. Retrieved from: https://www.eitfood.eu/entrepreneurship/scale-risingfoodstars
[68] EIT Food (2024) 10 agrifood startups to watch in 2024. Retrieved from: https://www.eitfood.eu/news/10-agrifood-startups-to-watch-in-2024
[69] EIT Food (2022) Personalised nutrition for all! Retrieved from: https://www.eitfood.eu/projects/prize-based-challenge/personalised-nutrition-for-all
[70] https://innovafeed.com/en/
[71] https://umiami.com/en/home/

- **Magnum**[72] (recycling technologies) has developed a pioneering new recycling process to transform post-consumer mixed plastic waste, which would otherwise have ended up in landfill or an incinerator, into a resin with the same characteristics as virgin food-grade resin.
- **The Rainforest Company**[73] (healthy food), founded in 2016 provides natural food products and specialises in vegan, superfoods, acai, organic, healthy food products, and transparency.

2.1.4. Private investments

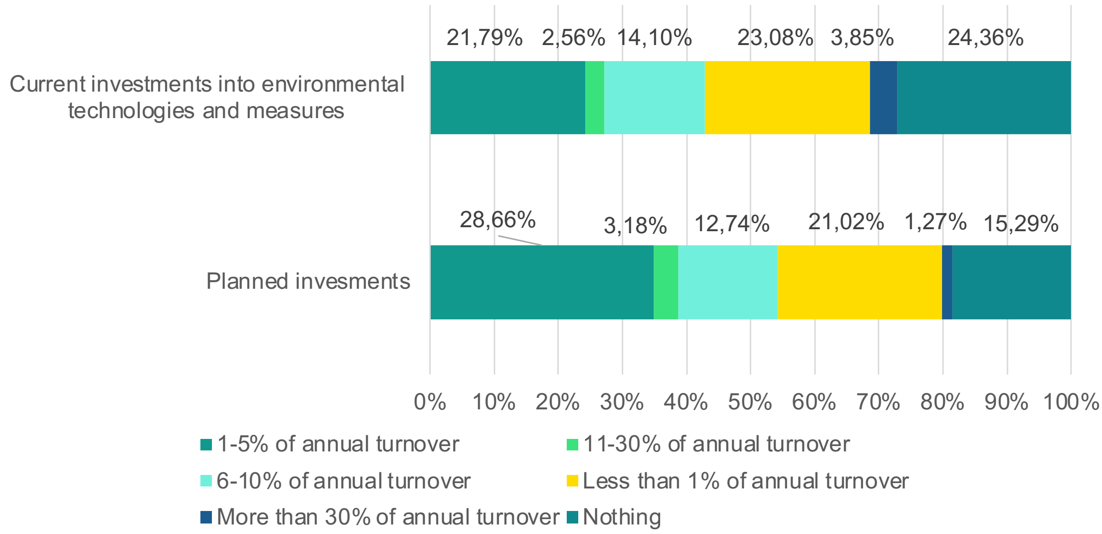
The 2019 European Investment Bank (EIB) report underscores that the sector's total annual private investment R&D of EUR 3 bn (EU) is significantly lower than that of other key areas of the European economy, like the health sector, at EUR 41 bn, or the information technology sector, at EUR 34.3 bn[74]. Other studies also highlight that, while equity investment deals between 2007 and 2020 increased in the EU and the US, the overall volume of equity investments in the EU lags behind that of the US with EUR 43 bn and EUR 139 bn, respectively, over the period 2007 to 2020[75].

In general, the agri-food industrial ecosystem requires more financing to close the financing gap in general for the sector, which according to the FI Compass reports, was roughly EUR 47 bn in 2017, and increased towards EUR 62 bn in 2022[76] [77]. This is reflected by the Eurobarometer survey results that reveal that 29% of agri-food companies do not invest in resource efficiency, while 46% of companies invest less than 5% of annual revenue in resource efficiency.

The findings from the EMI survey complement the Eurobarometer survey results as indicated in Figure 11. The data indicates that the **majority of companies invest less than 1% or between 1 and 5% of annual turnover in environmental technologies and measures (56%).** While certain categories of investments are increasing, e.g. the share of companies planning to invest 1-5% of annual turnover increased from 22% of current investments to 29% in planned investments, the number of companies making larger investments will likely decrease. For example, 14% of companies currently report 6-10% of annual turnover, however this investment bracket decreases to 13% in planned investments. **These results suggest that the financial resources of the companies themselves in agri-food will not be enough to finance green transformation of the agri-food industrial ecosystem**.

[72] Plastics Europe (n.d.) Magnum becomes the world's first ice cream brand to use recycled polypropylene plastic in its packaging in SABIC initiative. Retrieved from: https://plasticseurope.org/case-studies/magnum-becomes-worlds-first-ice-cream-brand-to-use-recycled-polypropylene-plastic-in-its-packaging-in-sabic-initiative/
[73] https://therainforest.com/
[74] European Investment Bank (2019) Feeding future generations How finance can boost innovation in agri-food. Retrieved from: https://www.eib.org/attachments/thematic/feeding_future_generation_en.pdf
[75] European Commission (2023) Food Systems. Research and innovation investment gap study: policy report. Retrieved from: https://op.europa.eu/en/publication-detail/-/publication/1747dc15-be80-11ed-891213 01aa75ed71a1
[76] Fi-Compass (2023) Financing gap in the agriculture and agri-food sectors in the EU. Retrieved from: https://www.fi-compass.eu/library/market-analysis/financing-gap-eu-agricultural-and-agri-food-sectors
[77] Fi-compass (2020) Financial needs in the agriculture and agri-food sectors in the European Union.

Figure 11: Level of investment of business in agri-food into green technologies



Source: EMI Enterprise Survey 2024, n=706

One-third of companies overall and more than one-half of high-emitting businesses reported access to capital as a major obstacle. Following the results from the Eurobarometer, only 15% of agri-food companies received private funding from bank, investment company or venture capital to produce green products or services, compared to 43% that received funding for enhancing resource efficiency.

In terms of the priorities that underpin private investments, recent studies indicate that investors and lenders prioritise but remain cautious with investments related to Environmental, Social and Governance (ESG) . For example, an Invesco 2021 survey indicates that 79% of surveyed investors declared that sustainability was an important factor in their investment decisions[78]. A further study found that 87% of financial institutions have implemented strategies to assess whether their selected clients (in the case of banks) or investees (in the case of investors) are aligned with the 1.5 degrees Celsius target[79].

The year 2023 saw a global downturn in venture capital investments globally, which also affected the agri-food industrial ecosystem. In total a 49% global decrease in funding raised in 2023 was observed compared to 2022[80]. Europe experienced a slightly smaller impact, with a 14% year-over-year decline in funding from 2023 as compared to 2022.

Venture capital investments tracked in the Crunchbase and NetZero Insights data set. The data set looks at venture capital investments in young companies (age 10 years or less) and gives insights into the amount of investment related to the green transition, as well as investments related to technologies underpinning the transition, notably biotechnology, recycling technologies, clean production technologies, renewable energy technologies, as well as circular business models. Venture capital data remain sufficiently well reported that general trends can be observed however some data lags for the most recent year (2023) may be present.

Venture capital investments in the agri-food industrial ecosystem related to the green transition were, in the year 2022 not at all impacted by the venture capital downturn cited in the literature. That being said, the effects of the downturn were rather felt in 2023,

---

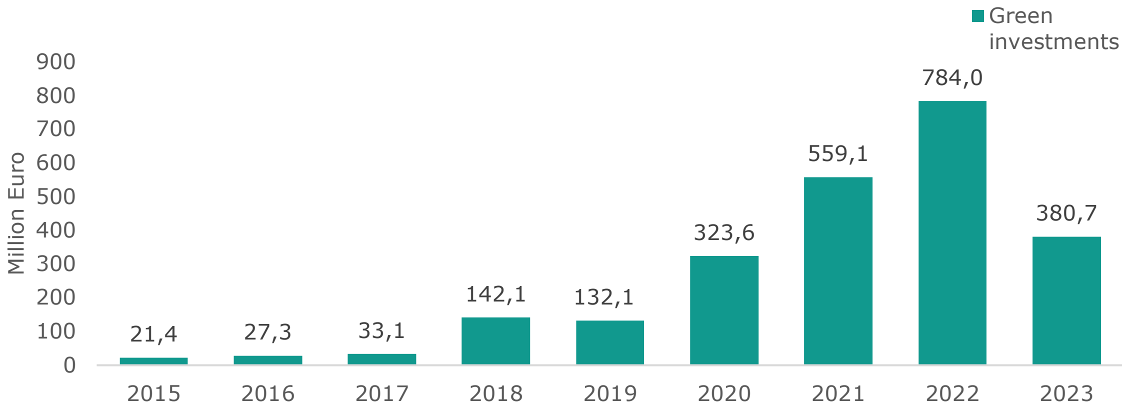
[78] Invesco (2021) Invesco Global Factor Investing Study. Retrieved from: https://www.invesco.com/content/dam/invesco/emea/en/pdf/Invesco-Global-Factor-Investing-Study-2021-EMEA.pdf

[79] Oliver Wyman and CDP (2023) Stepping up: Strengthening Europe's corporate climate transition. Retrieved from: https://www.oliverwyman.com/content/dam/oliver-wyman/v2/publications/2023/feb/cdp-europe-report.pdf

[80] AgFunder (2024) Global Agri-foodTech Investment Report 2024. Retrieved from: https://agfunder.com/research/agfunder-global-agrifoodtech-investment-report-2024/

though the dataset may still have some data lags for this year in terms of overall VC investments captured. Overall, the mounting trends gives evidence to the increasing opportunities related to the green transition in the agri-food industrial ecosystem, overarchingly supported through major policies giving clear signals to investors such as the European Green Deal.

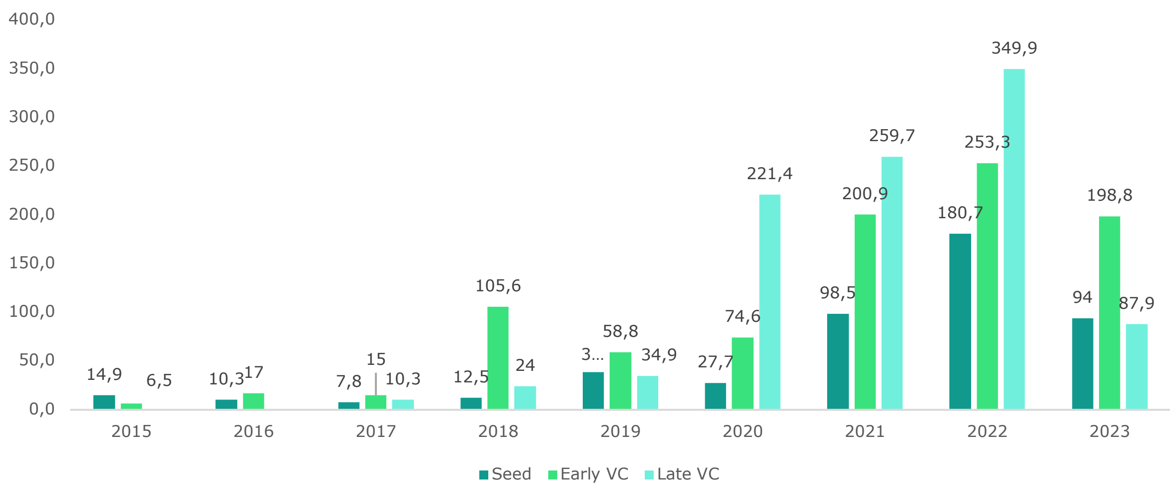
Figure 12: Venture capital investment into agri-food young companies – green transition



Source: Technopolis Group based on Crunchbase and Net Zero Insights

In terms of the venture capital investment stages in the green transition of agri-food startups, Figure 13 presents these according to seed, early venture capital (VC) and late VC. It is apparent that late VC funding dominates until 2022, however 2023 experiences a sharp decline especially in late VC funding rounds contributing to the overall downturn, a trend that is also observed in other data sets[81]. By comparison, early VC funding remained comparable stables between 2021 to 2023, as well as seed stage funding.

Figure 13: Venture capital investments stages into green transition of agri-food startups

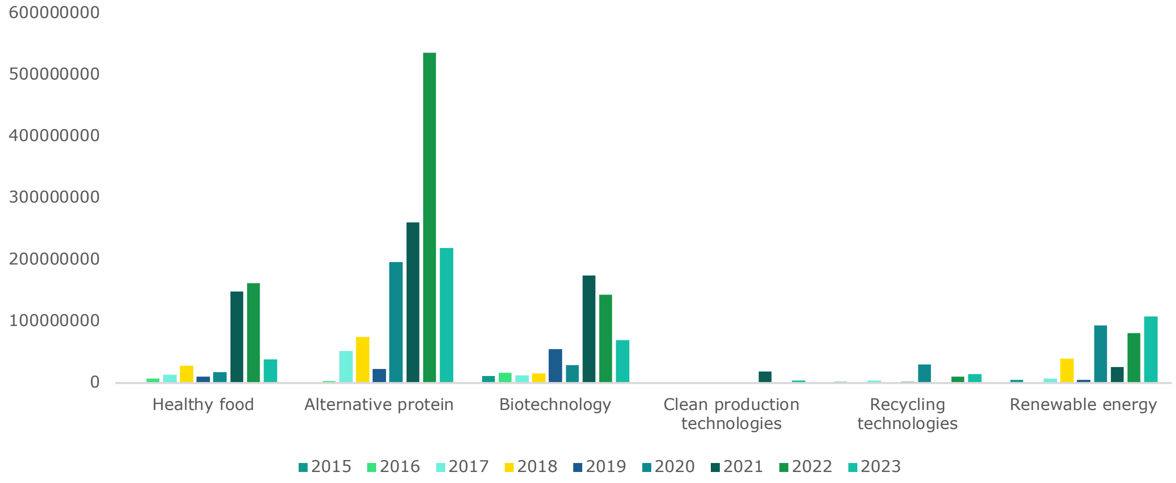


Source: Technopolis Group based on Crunchbase and Net Zero Insights

Investments related to advanced technologies showcase that alternative proteins is attracting the most VC investments over the period 2015-2023 (see Figure 14), highlighting the relative importance of alternative proteins as a topic for young companies, attracting considerable amounts of investments.

[81] AgFunder (2024) Global Agri-foodTech Investment Report 2024. Retrieved from: https://agfunder.com/research/agfunder-global-agrifoodtech-investment-report-2024/

Figure 14: Details on the VC investments per technology 2015-2023 – agri-food startups in the green transition-



Source: Technopolis Group based on Crunchbase and Net Zero Insights

Details on the funding rounds of select young companies based on the Crunchbase and NetZero Insights dataset include:

- **Umiami** (alternative proteins) is a young company, founded in 2020 that has raised a total of EUR 89 m. In 2022, they went through a series A funding round, raising a total of EUR 56 m.
- **The Rainforest Company** (healthy food), has raised a total of EUR 36 m.
- **InnovaFeed** (alternative protein) has raised a total of EUR 437 m. They specifically raised EUR 237 m in 2022 in a series D funding round.

2.2. Framework conditions – assessment of the broader ecosystem supporting the green transition

To what extent do framework conditions such as public financing and skills support the green transition?

- The agri-food industrial ecosystem received **EUR 15.25 bn in support from the European Regional Development Fund** for the period 2014-2020. Projects that addressed specifically the **green transition of agri-food accounted for over EUR 5.19 bn.**

- **31% of the identified agri-food projects contribute to the green transition, while 9%** support the implementation of measures of **energy efficiency** and demonstration projects in SMEs and large companies.

- While the **Horizon 2020 programme funded EUR 1.3 bn** to projects classified under the agri-food industrial ecosystem, **Horizon Europe** has thus far provided **EUR 670.3 m** in funding. For **Horizon Europe, 42% of the EC funding** to agri-food projects contributes to the green transition thus far.

- **Critical skills gaps in the agri-food industrial ecosystem relate to sustainability skills, efficient use of resources and logistics skills, and bioeconomy related skills.** The share of professionals registered on LinkedIn and employed in the agri-food industrial ecosystem with skills relevant to the green transition attained 2.3% in 2024, down from 3.2% in 2022.

Framework conditions that support the green transition refer to various structural and institutional elements that create an enabling environment for businesses to transition towards more sustainable and environmentally friendly practices. These conditions are crucial for driving the adoption of green technologies and fostering circular economies. Key components of these framework conditions include the generation of underlying technologies, public policy, skills demand and supply and demand-side factors among others that are analysed in the sections below.

2.2.1. Public investments supporting the green transition

Public investments affect the attractiveness of the industrial ecosystem and advance the greening of the industrial ecosystem while also signalling a high-level commitment to sustainable development, making the ecosystem and the green transition therein more attractive to businesses, investors, and other stakeholders. In the context of this study, the **investments made in the green transition in the agri-food industrial ecosystem through the public policy programmes** – i.e., the European Regional Development Funds, Cohesion funds, and the Framework Programmes – are examined through the combination of the databases Cohesion Open Data and Kohesio, as well as the database Community Research and Development Information Service (Cordis).

A key source of public funding that enables the green transition is the **EU's regional development funds**. For this analysis, two data sources have been used and merged, namely the Cohesion Open Data maintained by the European Commission and the Kohesio data[82]. The latter contains more than 1.7 million projects and approximately 500 000 beneficiaries financed throughout the funding period 2014–2020[83]. For more information on the data sources and the approach, see the methodological report.

ERDF projects[84] that are related to the agri-food industrial ecosystem could be identified in the data based on the codes of economic activity and additional keyword searches in the project descriptions. The total number of **ERDF projects in the agri-food industrial ecosystem** that could be identified in 2014-2020 was 26 873, good for a total funding of EUR 15.25 bn. The analysis shows that **about 34%** (or EUR 5.19 bn) **of the funding to agri-food ERDF projects supported the green transition[85]**.

Some examples of agri-food projects supporting the green transition are described below.

Box 1. ERDF agri-food projects supporting the green transition

The Spanish ERDF project titled '**Improving energy efficiency in seed oil extraction'** was implemented between 2015 and 2019. Its goal was to replace the existing seed oil extraction system with one that utilizes the best available technology, aiming to enhance energy savings. Falling under the energy efficiency area, the project received an EU budget of EUR 456 589.

A Hungarian ERDF project on the Development of **variants of dairy products** with proven health-protection effect based on robotic, precision-driven food raw material production using unique active ingredient combinations and innovative technologies ran from 2019 to 2022. The project developed and introduced dairy products that were not found on the market or had biological value in several respects that match modern dietary trends and health-conscious dietary needs and felt under the area of biotechnology. The project received a total EU funding of just under EUR 3.8 m.

Source: Technopolis Group based on Kohesio

---

[82] More information on the analyses and databases consulted is found in the methodological report accompanying this report: https://monitor-industrial-ecosystems.ec.europa.eu/about/monitoring-framework

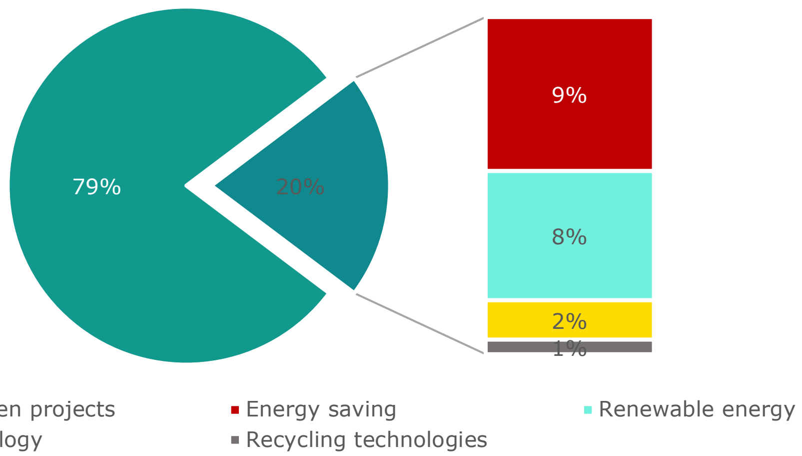
[83] European Union (2022) Linking data: Kohesio platform. Retrieved from: https://data.europa.eu/en/publications/datastories/linking-data-kohesio-platform

[84] The European Regional Development Fund (ERDF) supports projects aimed to strengthen economic, social and territorial cohesion in the European Union. It aims to correct imbalances between regions enabling investments in a smarter, greener, more connected and more social Europe that is closer to its citizens. The ERDF finances programmes in shared responsibility between the European Commission and national and regional authorities in Member States.

[85] The projects related to the green transition were filtered in the same manner, using a selected list of green keywords that were also constructed for other parts of the data collection in this project.

In terms of number of projects, 31% of the identified agri-food projects contribute to the green transition (or 8 311 projects). Of this set of green projects, **21% are active in advanced green technologies**, such as energy savings and renewable energy technologies. In particular, Figure below shows that 773 projects (9%) support the implementation of measures of energy efficiency and demonstration projects in SMEs and large companies, and 649 projects (9%) invest in renewable energy sources. As an illustration of the latter, biomass-related projects focus mostly on the installation of agricultural methanisation unit in biomethane injection and solar projects mainly support the installation of photovoltaic solar panels on agriculture infrastructure. In the food industry, an example is the construction of a modern fruit dryer using waste heat from a biogas station to replace an outdated system, significantly reducing natural gas consumption and improving energy efficiency.

Figure 15: Share of projects in 'advanced green technologies' in the total of ERDF agri-food projects that contribute to the green transition



Source: Technopolis Group based on Kohesio

EU Research and Development Framework Programmes

The study team has also analysed the funding stemming from the EU Framework Programmes for Research and Innovation, and in particular Horizon 2020 (2014-2020) and Horizon Europe (2021-2027), to initiatives and projects active in the agri-food industrial ecosystem[86].

While the Horizon 2020 programme funded EUR 1.3 bn to projects classified under the agri-food industrial ecosystem, Horizon Europe has thus far[87] provided EUR 670.3 million in funding.

Slightly **more than half of the EC related H2020 funding to agri-food projects contributed to the green transition**. For Horizon Europe, **42% of the EC funding** to agri-food projects contributes to the green transition thus far. These shares point towards the high importance of the green transition, as supported by the Framework Programmes.

An example of an agri-food project funded under Horizon 2020 supporting the green transition is described in Box 2.

[86] The methodological report provides detailed insights into the methodology. In particular, the CORDIS data have been merged with the relevant EuroSciVoc data. EuroSciVoc connects projects to relevant scientific concepts, providing a deeper understanding of the research focus.

[87] Cut-off date: March 2024. The funding period of Horizon Europe has not been finalised yet.

Box 2. Horizon 2020 and Horizon Europe agri-food projects supporting the green transition

The project FARMYNG[88] is funded under **Horizon 2020,** under the pillar "Industrial Leadership" and programme "Leadership in enabling and industrial technologies (LEIT) – Biotechnology" and is coordinated by Ÿnsect. The project started in April 2019 and brings together 19 key players in the bioeconomy value chain. The EU contribution to the project is EUR 19.6 million. FARMYNG aims to develop the breeding and transformation of mealworms (i.e., insect proteins) on an industrial and automated scale for the production of animal nutrition.

FARMYNG intends to industrialise the farming of an insect called the *Tenebrio molitor* to produce premium proteins for animal feed and fertilizers. It aims to establish the largest global fully automated flagship industrial plant to produce premium proteins from insects. The project aims to produce 1.500 tonnes of protein and 400 tonnes of oil per month.

Source: Cordis

2.2.2. Skills supply and demand underpinning the green transition

The agri-food industrial ecosystem is currently challenged to adapt their practices and technologies in response to climate change, the increased risk of infectious diseases and pests, and the need and demand for more sustainable approaches and efforts to reduce emissions and pollution. As a result, the agri-food industrial ecosystem requires **new skills and human capital, such as green skills,** to ensure a sustainable and competitive sector. At the same time, the transition pathway outlines some **critical skills gaps**, including sustainability skills, efficient use of resources and logistics skills, and bioeconomy related skills posing a particular challenge[89]. In a recent report, the OECD stated that the agriculture and food sector has the highest rate of skills misalignments overall economic industrial ecosystems. A 2023 Cedefop report underlines that the future of agri-food skills should aim at sustainability and soft skills and should focus on skills related to resource and energy management[90].

To address these challenges, several initiatives have been set up. For instance, the Agri-Food Pact for Skills partnership[91], coordinated by FoodDrinkEurope and Copa-Cogeca, aims to upskill and reskill the current workforce and make the agri-food industrial ecosystem more attractive to young people, while providing a career and life-long learning for both employers and workers. Vocational training programmes such as Agri-food4Future[92] provide support for meeting the needs of the agri-food industrial ecosystem of the future. In addition, EIT Food organises initiatives aimed at gaining practical skills and knowledge in circularity, sustainability, and innovation in the agri-food industrial ecosystem, e.g., CircularAgri-food Autumn School[93].

In order to provide insights into the skills demand and skills supply in the agri-food industrial ecosystem, this study draws upon two databases, namely the Cedefop database and LinkedIn[94].

Skills demand

Skills demand in the agri-food industrial ecosystem has been analysed following the skills intelligence insights of Cedefop, the European Centre for the Development of Vocational Training[95]. This dataset covers the EU27 Member States (plus UK) and is based on the

[88] European Commission (2024) FlAgship demonstration of industrial scale production of nutrient Resources from Mealworms to develop a bioeconomY New Generation. Retrieved from: https://cordis.europa.eu/project/id/837750/reporting
[89] European Commission (2024) Transition pathway for the agri-food industrial ecosystem.
[90] Cedefop (2023) Growing green: how vocational education and training can drive the green transition in agri-food. Luxembourg: Publications Office. Policy brief. Retrieved from: http://data.europa.eu/doi/10.2801/305793
[91] https://www.agri-food-pact4skills.eu/
[92] https://agrifood4future.com/
[93] https://learning.eitfood.eu/courses/inspire-circular-agrifood
[94] More information on the data sources, the approach taken, and the limitations of the data, is found in the methodological report.
[95] https://www.cedefop.europa.eu/en/tools/skills-online-vacancies

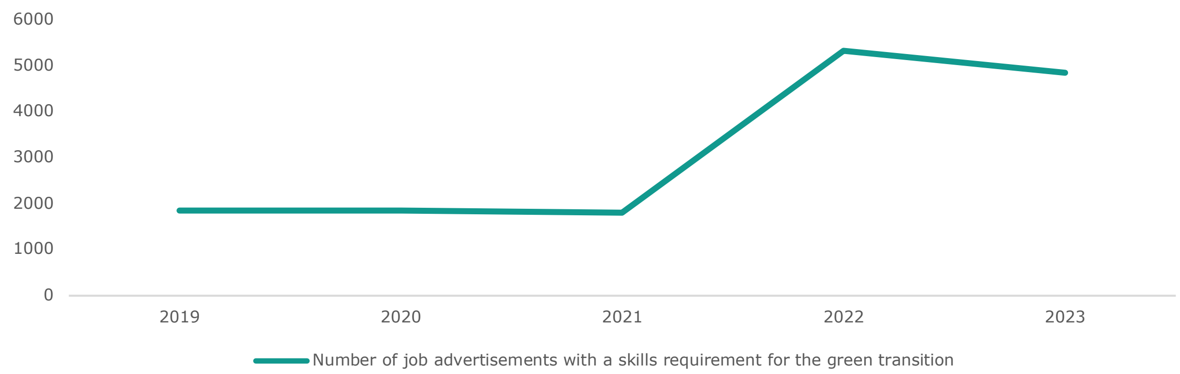
collection and analysis of more than 530 online job advertisement sources (424 distinct websites) which are open-access sites. The dataset provides information on most requested occupations and skills across European countries based on established international classifications, e.g., ISCO-08 for occupations, ESCO for skills, and NACE rev. 2 for sectors.

These websites reflect the characteristics of the local labour markets in terms of geographical distribution, ranging from 50 sites in Belgium and the Netherlands, to three in Luxembourg. For each job advertisement, there is data on the characteristics of the job, the employer, and job requirements[96].

Specific to the agri-food industrial ecosystem[97], there were **1 331 438 unique job advertisements** from companies between 2019-2023 in the EU27[98]. These job advertisements have been text-mined and the required skills analysed from the perspective of the green transition. Green skills have been identified as skills related to environmental protection, environmental services, environmental policy, environmental sustainability, environmental standards, low carbon technologies, renewable energy, the circular economy including circular design and recycling, and clean production technologies and business models related skills.

The share of online job advertisements requiring skills related to the green transition in 2023 was between 1-2%. The total number of job ads referring to green skills increased between the period from 2021 to 2022 but has been stagnating over the year from 2022 to 2023.

Figure 16: Share of online job advertisements with a requirement for environmental skills



Source: Technopolis Group based on analysis of Cedefop data

Skills supply

To gain insights into the supply of skilled professionals, the **LinkedIn database** is consulted. In particular, LinkedIn is the largest professional network platform with rich information like profile summary, job title, job description and field of study, which can be used for the identification of skilled professionals with skills relevant to the green transition.

To capture the agri-food industrial ecosystem, the following categories have been included:

- Food and Beverage Services,
- Food and Beverage manufacturing,
- Ranching and Fisheries,

---

[96] This methodology has its limitations, as described in the methodological report. Some limitations are, for instance, that only online job advertisements are represented and that the volume and quantity of the data depend on the selection of portals and sources.

[97] In the case of the agri-food industrial ecosystem the dataset was filtered for the NACE industries as defined in the Annual Single Market Report.

[98] As a comparison, the total number of job advertisements were 1 707 508 in the case of mobility and 724 820

- Beverage Manufacturing,
- Dairy Product Manufacturing, and
- Farming.

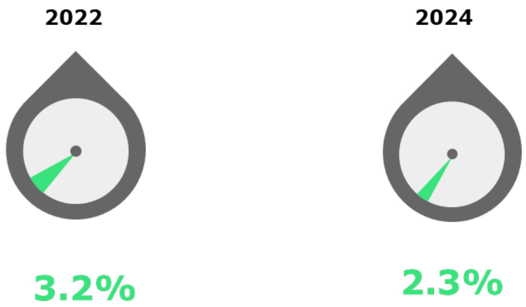
In order to capture the number of professionals working in the sector, occupations related to the industrial ecosystem have been taken into account.

Green skills have been identified as skills related to biotechnology, renewable energy technologies, circular business models and clean production technologies.

A total of 4.17 million professionals were found to be related to the agri-food industrial ecosystem on LinkedIn in April 2024. Of these, 1.4 million professionals were active in 'food manufacturing' specifically. While this means that an estimated 25.4% of food manufacturing professionals are active on the platform, it is to be noted that some jobs, functions and countries are better represented than others[99]. The data shows that about 45% of the agri-food professionals active on LinkedIn had a master's degree, 39% a bachelor's degree, 8% a Master of Business Administration, 6% an Associate Degree, and 2% a Ph.D.

Notably, within the registered professionals on LinkedIn employed in the agri-food industrial ecosystem, **2.3% indicated to have one type of green skill in 2024**, which is slightly lower than in 2022 where 3.2% were found to have at least one green skill (see Figure 17). The low shares can be partially attributed to the job titles professionals on LinkedIn have. Many agri-food professionals are food servers (4%), owners (4%), or cooks (2%) and it is hence not surprising that these do not list green skills (as identified above) on their profile. Along the same lines, several subpopulations are underrepresented in the data, such as professionals in agriculture.

Figure 17: Share of professionals in agri-food with skills relevant for the green transition



Source: Technopolis Group based on LinkedIn

2.2.3. Demand for green products

This section examines the demand among European citizens for novel food products, including plant-based alternatives, insects, and cultured meat, as well as their acceptance of these innovations. It also explores the growing consumer interest in nutrition, healthy, organic, and high-quality foods, reflecting shifting preferences towards more sustainable and health-conscious eating habits.

Demand for and acceptance of novel food products

A 2022 study from the European Consumer Organisation presents findings with regard to the perceptions of European consumers on the environmental impact of their eating

[99] The methodological report outlines how the report corrects this representativeness bias, i.e., by comparing LinkedIn population to the active population and derive a corrective weighting.

habits[100]. It found that consumers tend to underestimate the environmental impact of their own eating habits. On average, only slightly over 10% of those surveyed agree that what they eat has a negative impact on the environment, whereas 63.6% disagree. Also, the recent Eurobarometer poll found that "changing diet to more sustainable food" was only at the bottom of the list of actions European citizens undertake to address environmental issues. Nevertheless, most consumers say to pay some (47%) or a lot of attention (17.3%) to the environmental impact of their food choices[101]. Also, the 2023 EIT Food Trust Report[102] reports that the share of Europeans that take sustainability into account in their diet has remained stable at around 50%.

When it comes to environmental-friendly eating habits, two thirds (66.7%) of consumers state that they are open to changing eating habits that harm the environment[103]. Male respondents tend to be more reluctant to alter their eating habits than women. Yet, consumers have little appetite for innovative or high-tech options for replacing red meat, such as insects and cultured meat. On average, 10.3% of consumers would be willing to replace meat with insects, 13.4% would be willing to replace it with its cultured counterpart. A 2022 systematic literature review[104] underlines that food neophobia and uncertainties regarding safety and health present significant barriers to the adoption of such innovations. The survey of The European Consumer Organisation[105] indicates that there is more acceptance for plant-based alternatives as consumers tend to find traditional vegetarian foods the most attractive alternative sources of proteins.

Similar findings have also been underlined in the EIT Food Trust Reports. The report[106] indicates that the **openness of European citizens towards new food products is consistently low over the past years**, with about one third of Europeans being 'open'. The general concern is that those novel foods are 'industrial' and 'unnatural' as expressed in the report. Younger consumers, however, seem to be more open to novel food products than older consumers. The report further indicates that the consumers' confidence in food technology is rather low, even if the technology aims for healthier and more sustainable diets. The distrust is mostly related to innovation in food itself (e.g., the ingredients used), rather than in the way food is produced.

Demand for nutritious healthier, high quality and organic foods

The EIT Food Trust Report[107] indicates that the intention of European citizens to have a healthy diet has declined slightly from 60% in 2021 to 56% in 2023. Nevertheless, when examining the actual behaviour of citizens in 2023, **60% indicates to take into account health in the food choices they make**. Different consumer groups have varying levels of healthiness in their diets. The report indicates that consumers with a lower education, younger consumers, male consumers, and consumers living in a single household without children think the least about healthy diets.

---

[100] BEUC (2020) One bite at a time: consumers and the transition to sustainable food. Analysis of a survey of European consumers on attitudes towards sustainable food. Retrieved from: https://www.theconsumergoodsforum.com/global-learning-mechanism-resources/one-bite-at-a-time-consumers-and-the-transition-to-sustainable-food/
[101] BEUC (2020) One bite at a time: consumers and the transition to sustainable food. Analysis of a survey of European consumers on attitudes towards sustainable food. Retrieved from: https://www.theconsumergoodsforum.com/global-learning-mechanism-resources/one-bite-at-a-time-consumers-and-the-transition-to-sustainable-food/
[102] EIT Food (2024) Trust Report 2023. Retrieved from: https://www.eitfood.eu/reports/trust-report-2023
[103] BEUC (2020) One bite at a time: consumers and the transition to sustainable food. Analysis of a survey of European consumers on attitudes towards sustainable food. Retrieved from: https://www.theconsumergoodsforum.com/global-learning-mechanism-resources/one-bite-at-a-time-consumers-and-the-transition-to-sustainable-food/
[104] Pakseresht, A., Ahmadi Kaliji, S., & Canavari, M (2022) Review of factors affecting consumer acceptance of cultured meat. Retrieved from: https://doi.org/10.1016/j.appet.2021.105829
[105] BEUC (2020) One bite at a time
[106] EIT Food (2024) Truest Report 2023
[107] Idem.

According to the report, consumers express that they are struggling to find their way to healthier eating habits[108],[109]. It has been argued that retailers and food manufacturers could better assist them by, for example, providing simple and easy-to-understand information about product impact on health (e.g., standardised nutrition labels) or improving their product assortment.

Important in this regard is the trend of **reformulation**, which is driven by consumer demand but also by regulatory guidelines and food processors. Reformulation refers to the process of altering the processing of composition of food and beverage products to **improve their nutritional profile**[110]. This involves adjusting the composition of products by reducing or replacing certain ingredients, such as sugar, salt, fat, or artificial additives, or by adding beneficial ingredients, such as vitamins, proteins or fibres. Challenges in reformulation are in balancing the nutritional profile of the product with the taste, texture, and price. These aspects are critical in keeping consumer demand for the product[111]. Research has indicated that it might be preferable to reformulate gradually instead of the changing a recipe radically at once. FAO indicated that in 2022, 82 countries had food product reformulation programmes[112].

Organic farming, an agricultural method that aims to produce food using natural substances and processes (e.g., no chemical pesticides), is supported by the Common Agricultural Policy (CAP) and an EU Action Plan has been rolled out to **increase the consumption of organic products**[113]. Both globally and in the EU, the organic food market is growing and is expected to further expand. Recent statistics of IFOAM Organics Europe, a European umbrella organisation for organic food and farming, show that the organic retail sales in the EU have grown by 125% from 2013 until 2022 to EUR 45.1 bn. A small 3% decline in growth was, however, noticeable from 2021 to 2022[114].

---

[108] McKinsey & Company (2022) Hungry and confused: The winding road to conscious eating. Retrieved from: https://www.mckinsey.com/industries/consumer-packaged-goods/our-insights/hungry-and-confused-the-winding-road-to-conscious-eating

[109] EIT Food (2024) Trust Report 2023.

[110] Fanzo, J., McLaren, R., Bellows, A., & Carducci, B. (2023). Challenges and opportunities for increasing the effectiveness of food reformulation and fortification to improve dietary and nutrition outcomes. Food Policy, 119, 102515.

[111] FoodDrinkEurope (2022) The digital tool guiding reformulation. Retrieved from: https://www.fooddrinkeurope.eu/the-digital-tool-guiding-reformulation/?__im-NFTGmURZ=6778217616340149689

[112] FAO (2022) The state of food security and nutrition in the world 2022. Retrieved from: https://openknowledge.fao.org/server/api/core/bitstreams/6ca1510c-9341-4d6a-b285-5f5e8743cc46/content/sofi-2022/complementing-policies-agrifood-systems.html#ref-note-237

[113] European Commission (2021) Questions and answers: actions to increase organic production. Retrieved from: https://openknowledge.fao.org/server/api/core/bitstreams/6ca1510c-9341-4d6a-b285-5f5e8743cc46/content/sofi-2022/complementing-policies-agrifood-systems.html#ref-note-237

[114] IFOAM Organics Europe (2022) Organic in Europe. Production and consumption moving beyond a niche. Retrieved from: https://www.organicseurope.bio/about-us/organic-in-europe/

2.3. The impact of the industrial ecosystem on the environment

How is the industrial ecosystem's impact on the environment changing?

- The **agri-food industrial ecosystem is addressing its emissions-related challenges** while continuing to face significant challenges in other environmental areas. In particular, the sector **still lags behind in its impact on material extraction, water usage, and waste generation**.

- The share of agri-food in emissions from all sectors decreased from **37% in 2001 to 30% in 2021** due to faster growth in non-food emissions. Total emissions produced in the agri-food industrial ecosystem in the EU are following **a decreasing trend, with 1.32 gigatonnes of CO_2 equivalent (Gt CO_2eq) in 2001 to 1.16 Gt CO_2eq in 2021.**

- About **30%** of the world's energy is **consumed within agri-food**, and this energy use is responsible for one-third of the sector's greenhouse gas emissions. Energy intensity is also growing due to increased mechanisation, growing use of fossil fuel–based inputs, including pesticides and fertilizers and increasingly globalized supply chains.

- In the EU, many countries are at risk of **water scarcity** and vast parts of the continent having suffered severe droughts over the past years. Agricultural areas with intensive irrigation, islands in southern Europe, and large urban agglomerations are deemed to be the biggest **water stress hotspots.** While only around **9 % of Europe's total farmland is irrigated**, these areas still **account for about 50 % of total water use in Europe.**

The agri-food industrial ecosystem is traditionally known for its large environmental impact and its substantial use of (natural) resources. This section zooms in on select impact areas relevant for the industrial ecosystem and explores the environmental impact and performance of the industrial ecosystem and provides (long-term) trends in terms of several indicators, including overall emissions and food waste, energy consumption, resource degradation and biodiversity loss, and water scarcity and pollution. In doing so, it builds on secondary data sources such as Eurostat and FAOSTAT, which often represent parts of the agri-food industrial ecosystem but not per se the industrial ecosystem as a whole. Furthermore, this study reports on indicators developed through the Exiobase[115] dataset. This dataset allows to measure the environmental impact of industrial ecosystems via the environmental impact of both production and consumption. More information on this dataset and the constructed indicators is provided in the methodological report.

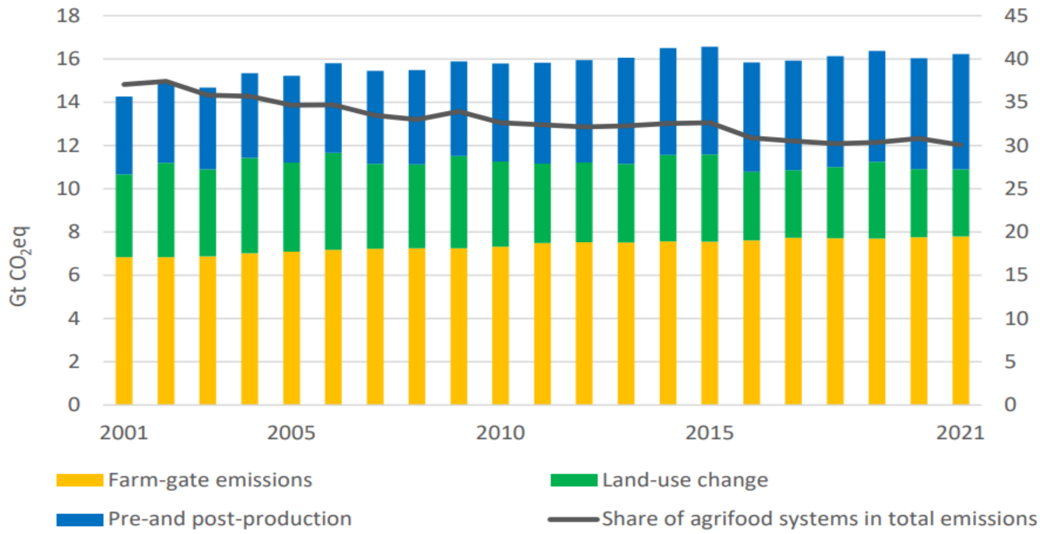
The following sections showcase the progression of the agri-food industrial ecosystem in relation to its overall emissions. While differing datasets showcase differing trends, it remains that the ecosystem is addressing its emissions-related challenges while **continuing to face significant challenges in other environmental areas. In particular, the sector still lags behind in its impact on material extraction, water usage, and waste generation.** These issues highlight the need for further improvements to mitigate the environmental strain caused by agri-food production and processes, even as some strides have been made in lowering emissions.

[115] About Exiobase. Retrieved from: https://www.exiobase.eu/index.php/about-exiobase

Emissions

According to FAOSTAT[116], the agri-food systems'[117] emissions totalled 16 billion tonnes of CO_2 equivalent (Gt CO_2eq) in 2021 globally, which represents an increase of 14% since 2001, with the most recent years (from 2017 onwards) being relatively stable (see Figure 18). The share of agri-food systems in emissions from all sectors decreased from 37% in 2001 to 30% in 2021 due to faster growth in non-food emissions. The agri-food system emissions per capita decreased over the period. Farm gate emissions, emissions that occur directly on the farm during the production of agricultural products, accounted for nearly half of total agri-food systems emissions globally in 2021. Comparably pre- and post-production processes accounted for one-third, and land-use change one-fifth of the total agri-food systems emissions.

Figure 18: Global agri-food system emissions (2001-2021)

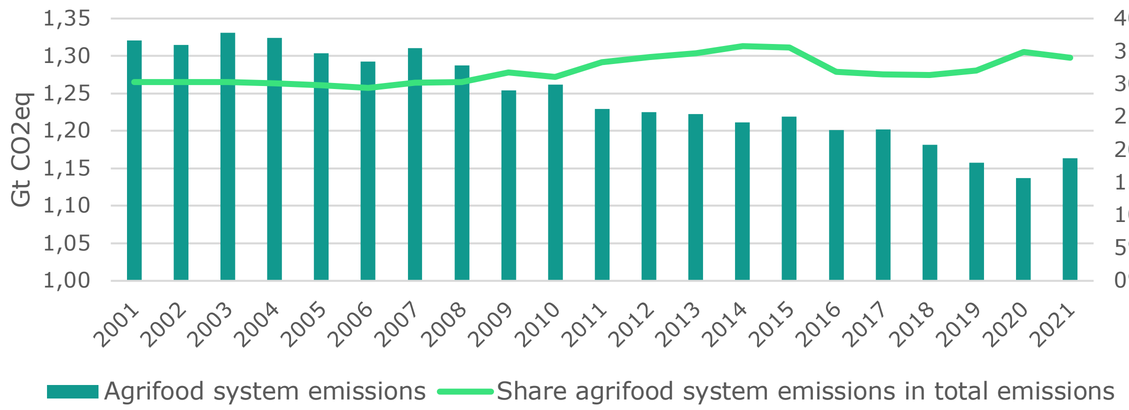


Source: FAOSTAT[118]

Focusing on the **EU**, FAOSTAT data[119] shows that the total emissions produced in the agri-food system are following a decreasing trend, with 1.32 gigatonnes of CO_2 equivalent (Gt CO_2eq) in 2001 to 1.16 Gt CO_2eq in 2021 (see Figure 19) although **an increase is noticeable from 2020 to 2021**. This trend is in contrast with the global trend depicting an increase in total agri-food system emissions (see Figure 20). When examining the composition of the emissions, in Europe, the majority of the emissions are farm gate emissions, closely followed by pre- and post-production emissions. The share of agri-food system emissions in the total emissions remains at approximately 30-35% over the past years, reflecting the fact that the total emissions in the EU27 are decreasing more rapidly than agri-food system emissions.

[116] FAO (2023) Agrifood systems and land-related emissions. Global, regional and country trends, 2001-2021. Retrieved from: https://openknowledge.fao.org/server/api/core/bitstreams/487c7f4e-91ff-4d23-b1e4-f72dd867e939/content
[117] FAO defines agri-food systems as all the interconnected activities and actors involved in getting food from field to fork. This broad definition encompasses everything from agricultural production and processing to distribution, consumption, and waste management." (https://www.fao.org/evaluation/highlights/agri-food-systems/en).
[118] FAO (2023) Agrifood systems and land-related emissions. Global, regional and country trends, 2001-2021.
[119] FAO (n.d.) FAOSTAT. Food and agriculture data. Retrieved from: https://www.fao.org/faostat/en/#home

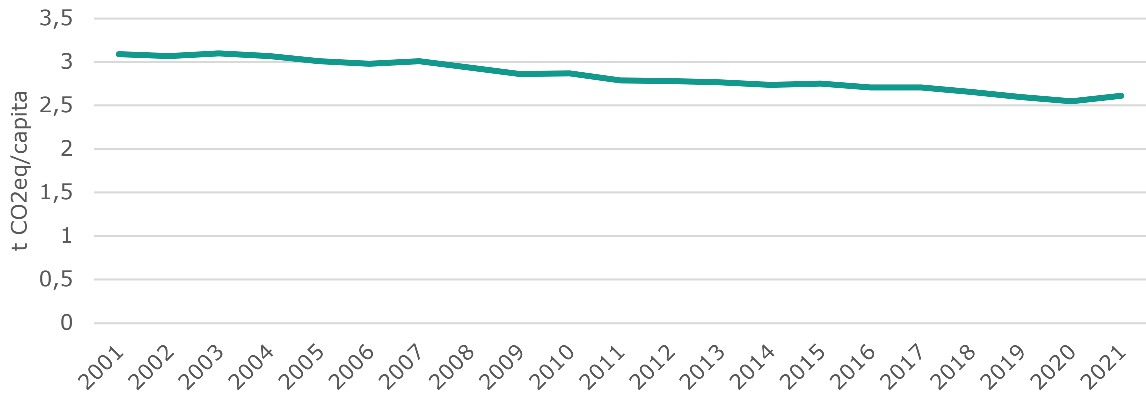
Figure 19: Agri-food system emissions and share in the total emissions (EU27, 2001-2021)



Source: IDEA Consult based on FAOSTAT

The per capita emissions from the agri-food system in the EU27 are also decreasing over the considered period (2001-2021), although a modest increase is noticeable from 2020 to 2021 (see Figure 20). When compared to the other world regions, Oceania is the largest per capita emitter, followed by the Americas. Africa is in 2021 around 2 tonnes CO_2 equivalent per capita, and Asia is the lowest with 1.5, but in Asia, there is an increasing trend over the considered period.

Figure 20: Per capita emission from agri-food systems in (EU27, 2001-2021)



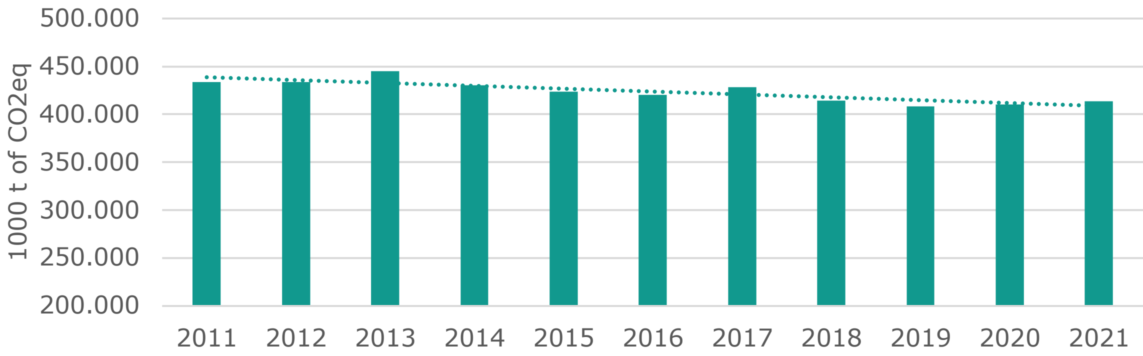
Source: IDEA Consult based on FAOSTAT

Furthermore, the Common Agricultural Policy (CAP) dashboard[120] reported on greenhouse gas emission indicators from **agriculture in the EU**. The total net greenhouse gas emission from agriculture has decreased significantly from 1990 to 2021 from 580 to 410 million t CO_2eq (see snapshot in Figure 21). The figures also show that the ammonia emissions from agriculture have diminished from 4.8 to 3.1 million tonnes over the same period. At the same time, statistics from the European Environment Agency (EEA), focussing on non-CO_2 emissions (CH_4 and N_20 which are responsible for 48% and 31% of GHG emissions from agriculture, respectively) show that EU agricultural emissions decreased slightly between 2005 and 2021[121].

[120] European Commission (n.d.) CAP Dashboard. Climate Change and Air Quality. Retrieved from: https://agridata.ec.europa.eu/extensions/DashboardIndicators/Climate.html

[121] European Environment Agency. (2023). Greenhouse gas emission from agriculture in Europe.

Figure 21: Greenhouse gas emissions from agriculture in the EU (including cropland and grassland) (2010-2021)



Source: IDEA Consult based on CAP dashboard (climate change and air quality)

The recent 2024-2033 outlook report of FAO and the OECD[122] indicate that by 2033, direct agricultural greenhouse gas emissions are on average projected to decline in the EU, within the natural limitations of the sector. This encompasses a decline of 4% in Western Europe and European Union, combined with a 1% increase in Eastern Europe.

Exiobase provides additional insights into the greenhouse gas emissions of the agri-food industrial ecosystem in terms of its consumption and production account for the period of 2016 to 2021 and in some instances also 2022. This analysis differs from the data presented above based on FAOSTAT in the methodology[123].

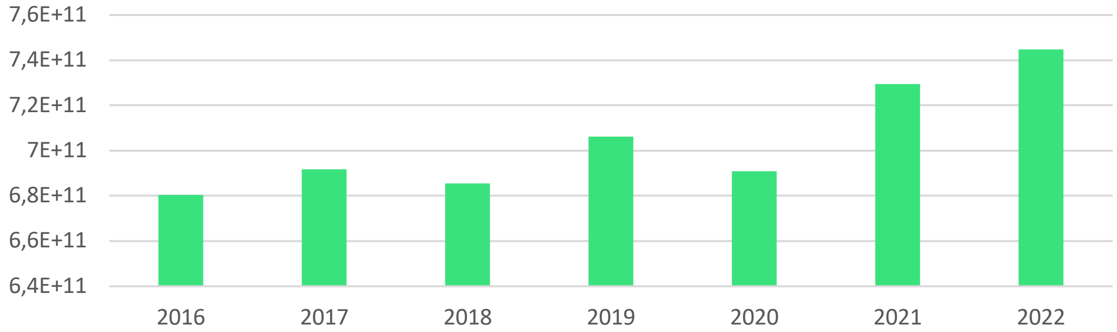
Figure 22 and 23 provide insights into the CO_2 emissions of the EU27 in megatons in the agri-food industrial ecosystem (both production and consumption account). In particular, Figure 22 shows that from 2020 onwards, there is an **increase in the CO_2 CO2 emissions** produced by all inputs needed for agri-food purchased by EU consumers (consumption account). Figure 23 depicts the trend in greenhouse gas emissions created in the process of producing goods in the EU agri-food industrial ecosystem. It is to be noted that there was a large increase in production account CO_2 emissions in 2019, which, despite a slight drop in 2020, remained relatively stable until 2021.

In general, the figures show that the bulk of CO_2 emissions comes from consumption, rather than production of agri-food.

[122] OECD & FAO (2024) OECD-FAO Agricultural Outlook 2024-2033. Retrieved from: https://doi.org/10.1787/4c5d2cfb-en.

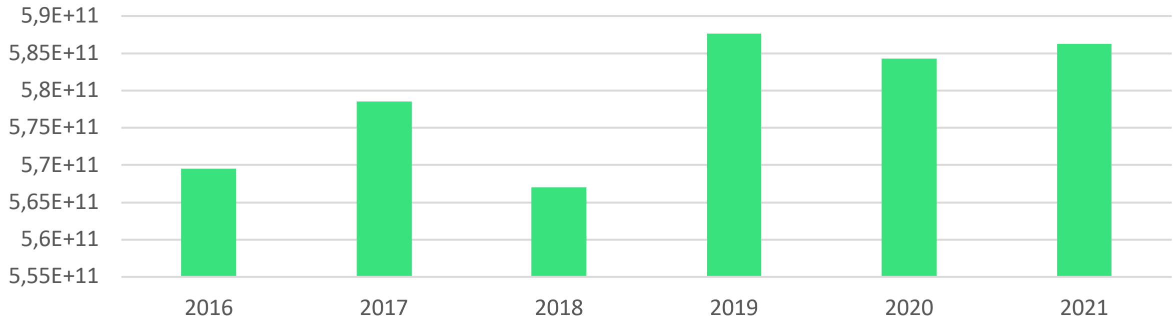
[123] In particular, FAOSTAT presents in its methodology note that "the GHG emissions used in the computation of the FAOSTAT Emissions Intensities indicator correspond to those generated within the farm gate. Additional emissions from upstream and downstream production and consumption processes and trade are excluded due to the lack of granular information needed for this analysis. This represents a simplification with respect to more complex estimations methods, typically based on life-cycle analyses (LCA), to which these FAOSTAT indicator data should not be compared." As the Exiobase indicators are consumption- (and production)-based, a type of LCA, they hence cannot be compared to the FAOSTAT data.
FAIOSTAT Domain Emissions intensities. Methodological note. Retrieved from: https://files-faostat.fao.org/production/EI/EI_e.pdf

Figure 22: Greenhouse gas emissions of the agri-food industrial ecosystem (CO_2 emissions in megatons) - consumption account



Source: Technopolis Group based on Exiobase

Figure 23: Greenhouse gas emissions of the agri-food industrial ecosystem (CO_2 emissions in megatons) - production account



Source: Technopolis Group based on Exiobase

Food waste

The problem of food waste has social, economic, and environmental consequences. It is highlighted as a challenge of global importance[124], and reflected in the Sustainable Development Goals (SDGs) through SDG 12.3 which aims to halve food waste by 2030[125]. The EU's Circular Economy Action Plan notes that, in the EU, about **20% of all food produced** is lost or wasted.

Eurostat estimated that over **59 million tonnes of food was wasted** in the EU[126], equalling **132 kilograms per inhabitant** in 2022. This was 127 kilograms per inhabitant in 2020 and 131 in 2021, suggesting that numbers are on the rise. Households are the largest source of food waste, generating 54% of the waste, with 46% of it arising from the food supply chain in 2022 (see Figure 24). In particular, 19% of the food waste (or more than 11.1 million tonnes) was lost during food processing and manufacturing, and 8% (or 4.6 million tonnes) is due to the primary production sector[127]. The sectors 'restaurants and food services' and 'retail and other distribution of food' accounted for respectively 15 kg and 11 kg of food waste per person (or 11% and 8% of the total food waste); however,

[124] Tchonkouang, R. D., Onyeaka, H., & Miri, T (2023) From Waste to Plate: Exploring the Impact of Food Waste Valorisation on Achieving Zero Hunger. Sustainability, 15(13), 10571. Retrieved from: https://www.mdpi.com/2071-1050/15/13/10571

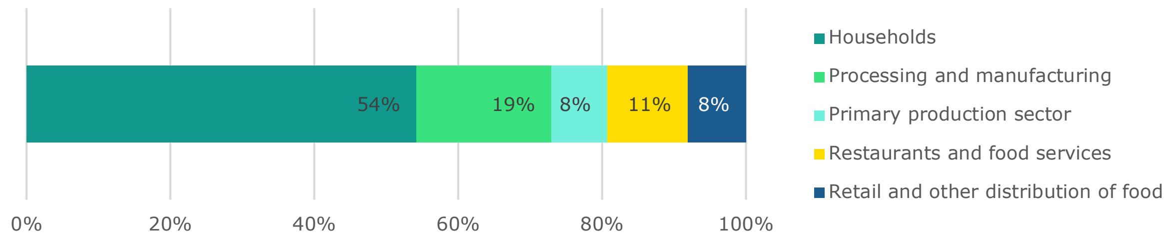
[125] SDG 12.3 calls for halving global per capita food waste at the retail and consumer levels by 2030 and reducing food losses along production and supply chains.

[126] according to the NACE rev.2 classification and by households, excluding food losses (food not harvested or food not authorised to be marketed for safety reasons).

[127] EUROSTAT(2024) Food waste and food waste prevention – estimates. Retrieved from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Food_waste_and_food_waste_prevention_-_estimates

the impact of the end of the COVID-19 lockdowns on these two sectors is still being analysed. Cyprus and Denmark showed the highest per capita food waste, mainly due to primary production and processing, while Portugal and Italy's household waste was the highest.

Figure 24: Food waste in the EU27 by main economic sectors (2022)



Source: IDEA Consult based on Eurostat (env_wasfw)

Food losses and waste translate into economic losses for farmers, higher consumer prices, and increased food insecurity, particularly for vulnerable groups[128]. Additionally, food waste causes significant environmental impacts, including wasted resources and greenhouse gas emissions. Food waste in the EU accounts for approximately 16% of total food system[129] greenhouse gas emissions[130].

The FAO estimates that globally, around 13% of food produced is lost after harvesting and before reaching retail markets[131], whereby fruit and vegetables account for more than half of the lost and wasted food, given their extremely perishable nature and relatively short shelf life. Cereals contribute a substantial 23% share of the total, for instance due to issues and inefficiencies in storage. Meat and dairy products represent a lower share by weight, which can be explained by the fact that households tend to waste fewer high-value products.[132]

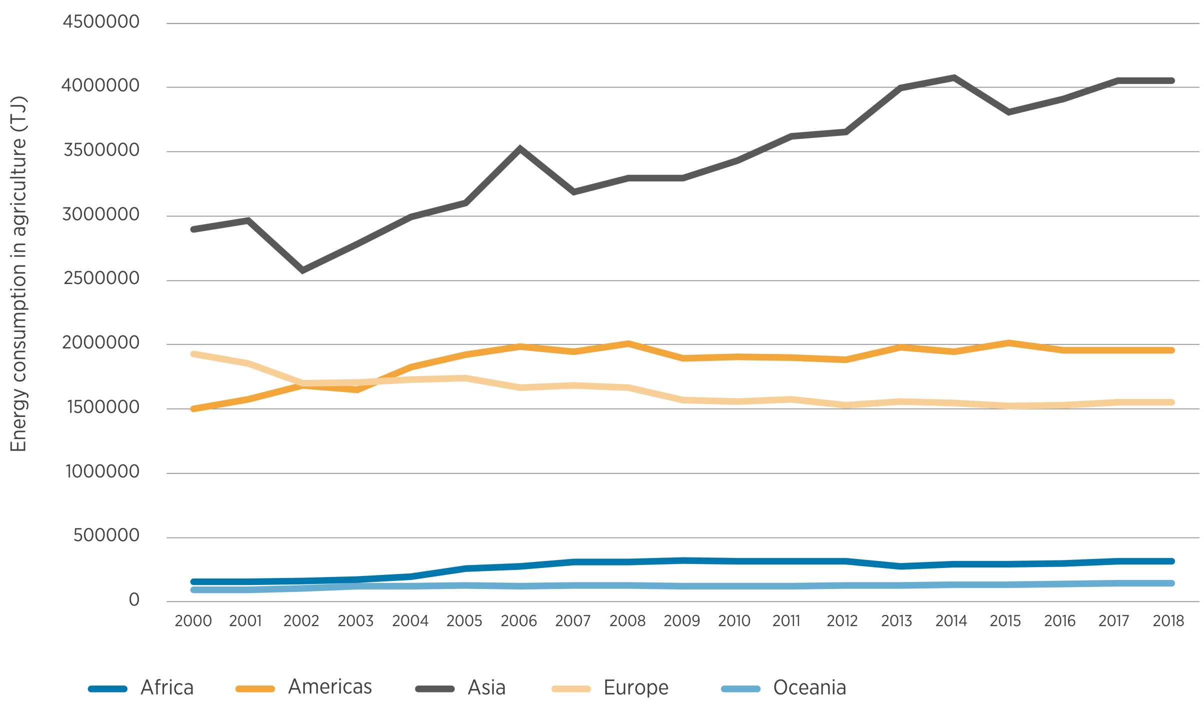
Energy consumption[133]

About **30% of the world's energy is consumed within agri-food systems[134]**, and this energy use is **responsible for one-third of the sector's greenhouse gas emissions**. From 2000 to 2018, **global energy consumption in agri-food systems increased by over 20%** with variations depending on world region (see Figure 25)[135]. Indeed, energy intensity is also growing due to increased mechanisation, growing use of fossil fuel–based inputs, including pesticides and fertilizers, globalized supply chains, growing demand for meat, dairy, and processed foods, and, to some extent, new food trends such as alternative proteins[136].

---

[128] FAO (2017) The future of food and agriculture – Trend and Challenges. Retrieved from: https://openknowledge.fao.org/server/api/core/bitstreams/2e90c833-8e84-46f2-a675-ea2d7afa4e24/content
[129] The definition of the food system covers the entire value chain, from primary production to consumption.
[130] JRC (2023) Less food waste could bring lower EU food prices and decrease greenhouse gas emissions. Retrieved from: https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/less-food-waste-could-bring-lower-eu-food-prices-and-decrease-greenhouse-gas-emissions-2023-07-06_en
[131] FAO (2019) The state of Food and Agriculture, moving forward on food loss and waste reduction, Retrieved from: https://doi.org/10.4060/CA6030EN
[132] OECD & FAO (2024) OECD-FAO Agricultural Outlook 2024-2033, Paris and Rome. Retrieved from: https://doi.org/10.1787/4c5d2cfb-en.
[133] IRENA & FAO (2021) Renewable energy for agri-food systems – Towards the Sustainable Development Goals and the Paris agreement. Abu Dhabi and Rome. Retrieved from: https://doi.org/10.4060/cb7433en
[134] See definition agri-food system as presented by FAO
[135] IRENA & FAO(2021) Renewable energy for agri-food systems – Towards the Sustainable Development Goals and the Paris agreement. Abu Dhabi and Rome. Retrieved from: https://doi.org/10.4060/cb7433en
[136] Global Alliance for the Future of Food (2023) Food systems account for at least 15% of all fossil fuels.

Figure 25: Energy consumption in agri-food systems, by region, 2000-2018



Source: FAOSTAT 2021, from IRENA & FAO (2021)

Inherently, the agri-food system is intertwined with the fossil fuel industry and is dependent on fossil fuels across the entire value chain. It was calculated that the agri-food system **accounts for at least 15% of global fossil fuel use annually**. Not only does this drive further climate change, but the risks also associated with dependence on fossil fuels have been highlighted throughout 2022–2023, with the war in Ukraine having significant effects on food supplies and prices. At the same time, the agri-food system also produces energy in the form of biofuels, biomaterials, and on-farm energy production. Yet, in some cases, this energy production also produces some less desirable side effects (e.g., negative environmental impact)[137].

Resource degradation and biodiversity loss

A recent study[138] supported by the UN Environment Programme (UNEP) underlines that the global **food system, including the whole value chain from agriculture and production to consumption, is the primary driver of biodiversity loss**. Currently, agricultural land (including natural grassland) accounts for almost half of the European territory (48%)[139]. However, deforestation and the conversion of land for agriculture and the intensification of agriculture reduce the quality and quantity of habitat available. As an illustration, agriculture alone has currently been identified as a threat to 24000 of the 28000 (86%) species at risk of extinction and the wildlife of marine systems is heavily affected by fishing[140]. Also, deforestation diminishes the resilience of the agri-food system against pests, pathogens, and climate change and intensive use of irrigation depletes ground water tables[141].

---

[137] idem

[138] Chatham House (2021) Food system impacts on biodiversity loss. Retrieved from: https://www.chathamhouse.org/sites/default/files/2021-02/2021-02-03-food-system-biodiversity-loss-benton-et-al_0.pdf

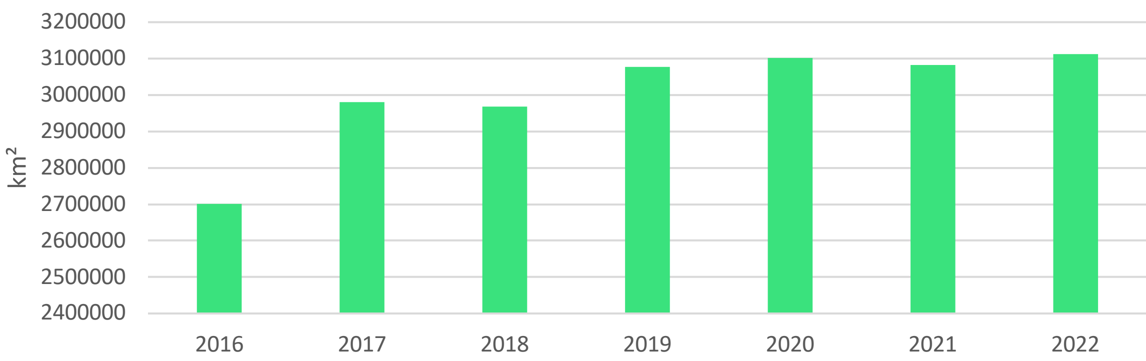
[139] Copa Cogeca (n.d.) European Farming. Retrieved from: https://www.copa-cogeca.eu/europeanfarming#b188

[140] Chatham House (2021) Food system impacts on biodiversity loss.

[141] World Bank Group (2023) Jobs, food and greening: Exploring implications of the green transition for jobs in agri-food.

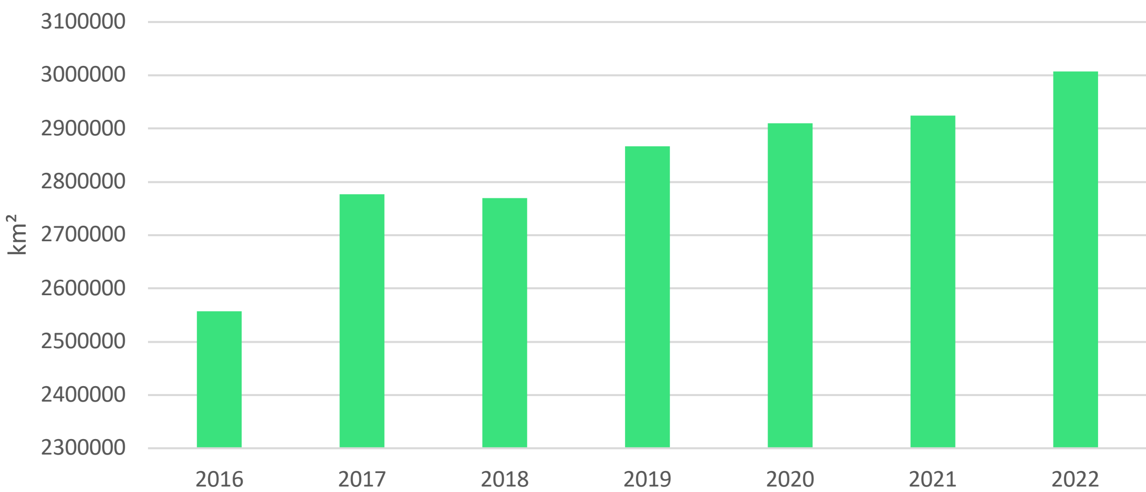
Exiobase indicators show that the **use of land by the agri-food industrial ecosystem for both food production and consumption in the EU is generally increasing over time** (see Figure 26 and 27). The Exiobase indicators on ecosystem damage as a result of the agri-food industrial ecosystem indicate that, over the past years, the ecosystem damage because of EU production has intensified, while that of EU consumption has stagnated from 2019 onwards. In addition, the Exiobase indicators provide insights into the amounts of used and unused materials[142] (**material extraction**) for the consumption and production related to the agri-food industrial ecosystem. The trends for both production and consumption in the EU are increasing, indicating that increasing amounts of materials are extracted due to the agri-food industrial ecosystem.

Figure 26: Land use (km²) of the agri-food industrial ecosystem - production account



Source: Technopolis Group based on Exiobase

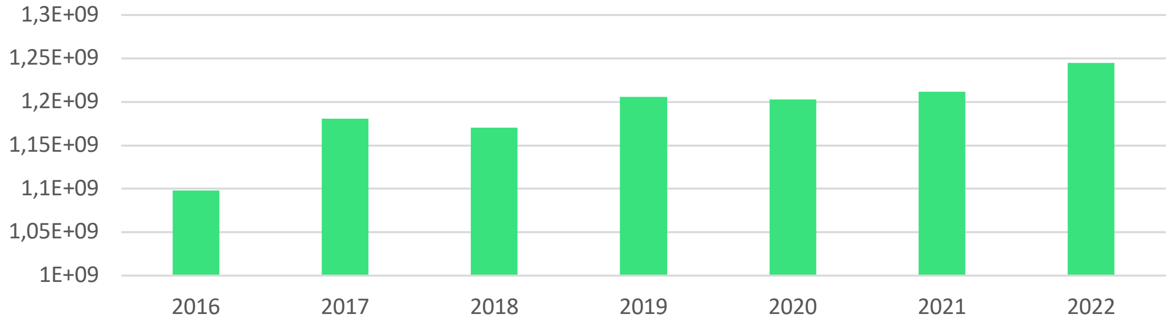
Figure 27: Land use (km²) of the agri-food industrial ecosystem - consumption account



Source: Technopolis Group based on Exiobase

[142] The methodological report outlines that these materials include used and unused crops and crops residue, grazing and fodder, forestry and timber, fisheries, non-metallic minerals, iron ore, non-ferous metal ores, coal and peat, and oil and gas

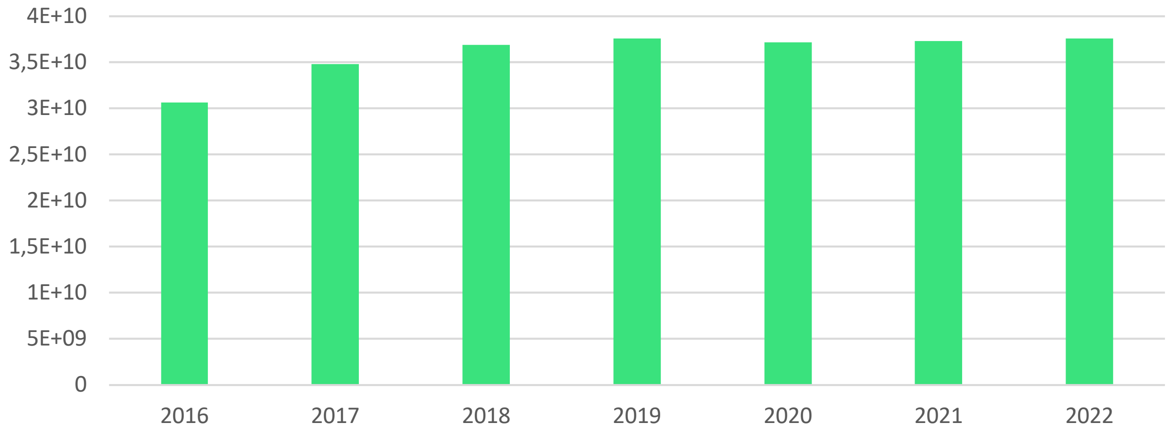
Figure 28: Ecosystem damage of the agri-food industrial ecosystem (in PDF on a square meter during a year) - production account



Note: PDF = Potentially disappeared Fraction of species

Source: Technopolis Group based on Exiobase

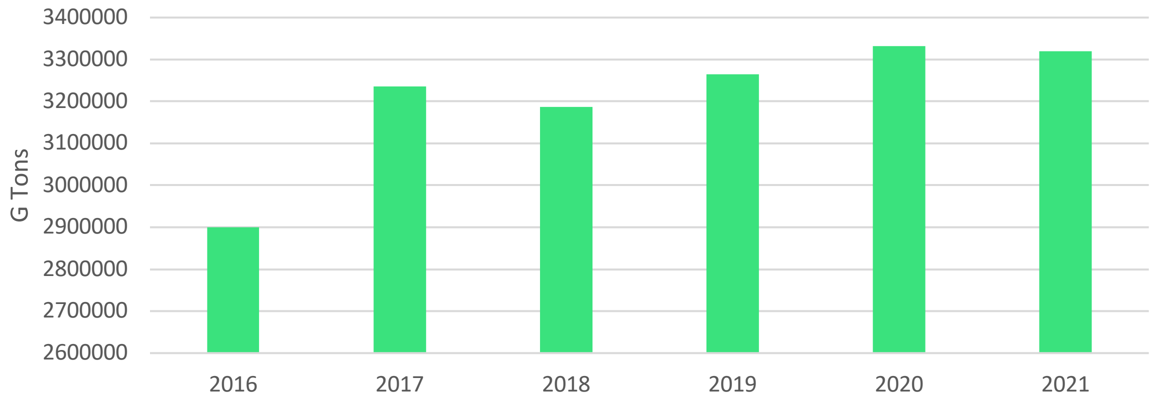
Figure 29: Ecosystem damage of the agri-food industrial ecosystem (in PDF on a square meter during a year) - consumption account



Note: PDF = Potentially disappeared Fraction of species

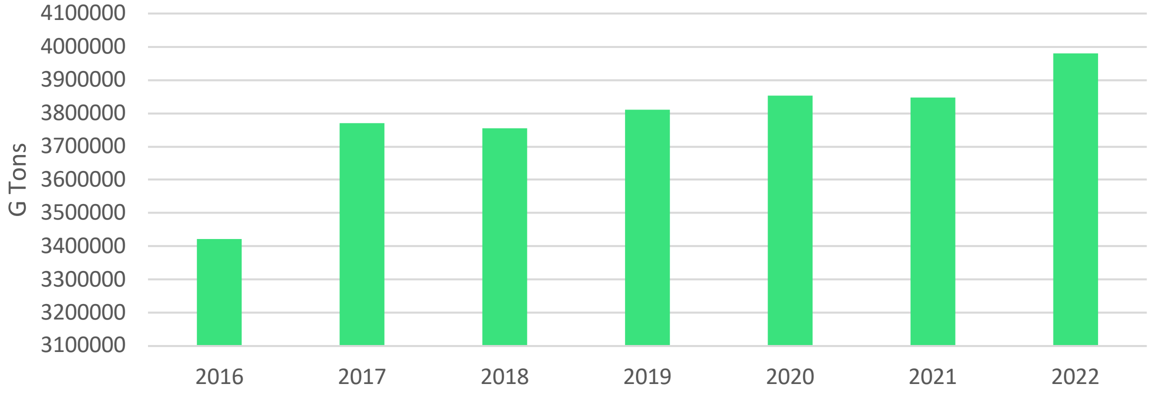
Source: Technopolis Group based on Exiobase

Figure 30: Material extraction of the agri-food industrial ecosystem (in G tons)– production account



Source: Technopolis Group based on Exiobase

Figure 31: Material extraction of the agri-food industrial ecosystem (in G tons)– consumption account



Source: Technopolis Group based on Exiobase

One of the underlying reasons for the resource degradation and biodiversity loss is the 'cheaper food paradigm'[143]. This paradigm suggests that the goal of producing food at lower costs requires increasing inputs such as fertilisers, pesticides, energy, land and water. Yet, this leads to a vicious circle, namely: the lower cost of food production leads to a bigger demand for food that must also be produced at a lower cost through more intensification and further land clearance.

In general, it is believed that the biodiversity crisis has intensified over the past years and that its impact is increasingly being felt by society, despite efforts like the Common Agricultural Policy (CAP)[144,145].

Water scarcity and pollution

The agri-food industrial ecosystem also causes water, soil, and air pollution and contributes to resource - especially water - scarcity.

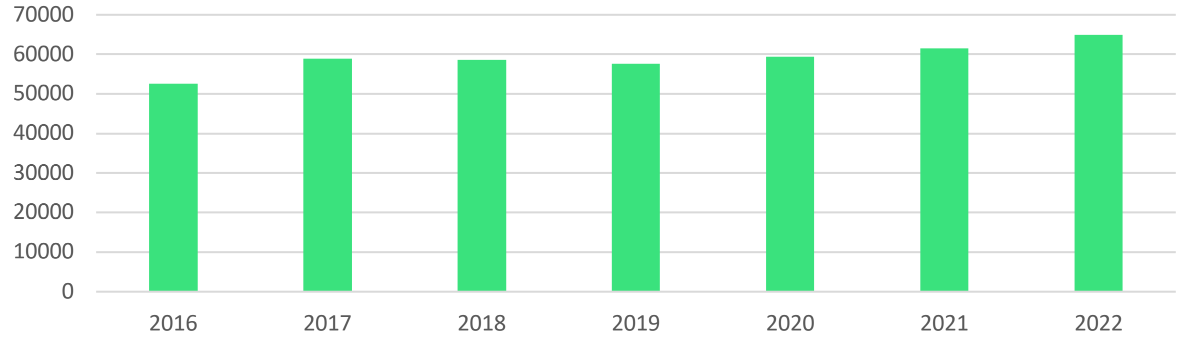
Water is a key input for agricultural production and the agri-food industrial ecosystem in general. In particular, the Exiobase indicators show that the total water consumption of the agri-food industrial ecosystem is generally increasing, both when considering the water consumption for the EU production of agri-food as well as for the EU consumption of agri-food (see Figure 32). Therefore, the growing risks of water scarcity due to climate change and global population growth, would mean that less water is available for agricultural and food production. As a consequence, that would imply that less food would be available, threatening food security and nutrition[146].

In the EU, many countries are at risk of water scarcity[147] and vast parts of the continent having suffered severe droughts over the past years[148]. Agricultural areas with intensive irrigation, islands in southern Europe, and large urban agglomerations are deemed to be the biggest water stress hotspots. The EEA[149] further indicated while only around 9 % of

[143] Chatham House (2021) Food system impacts on biodiversity loss.
[144] European Environmental Bureau (2022) New CAP unpacked… and unfit.
[145] European Court of Auditors (2020) Special Report 13/2020: Biodiversity on farmland: CAP contribution has not halted the decline.
[146] European Commission (2023) Water scarcity means less water for agriculture production which in turn means less food available, threatening food security and nutrition. Retrieved from: https://www.fao.org/newsroom/detail/water-scarcity-means-less-water-for-agriculture-production-which-in-turn-means-less-food-available-threatening-food-security-and-nutrition/en
[147] European Commission (n.d.) Water scarcity and droughts. Retrieved from: https://environment.ec.europa.eu/topics/water/water-scarcity-and-droughts_en
[148] European Environmental Bureau (2023) Ripple effect: Why Europe's water crisis demands a fundamental change in food production. Retrieved from: https://meta.eeb.org/2023/06/13/europes-water-crisis-demands-a-fundamental-change-in-food-production/
[149] EAA (2023) Water use in Europe — Quantity and quality face big challenges. Retrieved from: https://www.eea.europa.eu/signals-archived/signals-2018-content-list/articles/water-use-in-europe-2014

Europe's total farmland is irrigated, these areas still account for about 50 % of total water use in Europe. Nevertheless, improvements in water efficiency and management of water supplies have resulted in an overall decrease in total water abstraction of 19 % since 1990.

Figure 32: Water consumption of the agri-food industrial ecosystem (in million m³) – consumption account

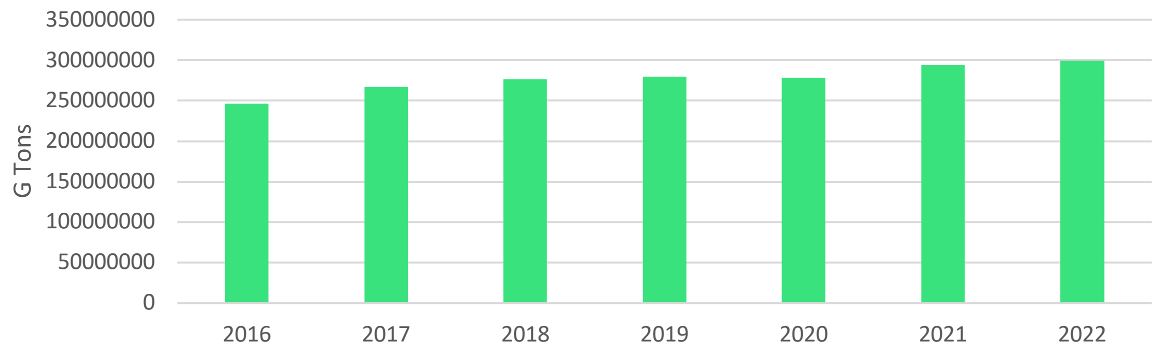


Source: Technopolis Group based on Exiobase

In addition, it is becoming increasingly apparent that current agricultural practices and intensive animal rearing are key drivers of Europe's extensive **soil pollution and degradation**. For example, the use of pesticides, intensive tillage and land use change can lead to soil erosion and soil biodiversity loss. Also, the application of animal manure on soil leads to pollution by heavy metals (zinc and copper) and antibiotics, especially in case of poor animal welfare standards[150].

In terms of air quality, ammonia emissions from agriculture in the EU are decreasing from 3.5 million tonnes of NH_3 in 2004 to 3.1 million tonnes in 2021[151]. Emissions of particulate matter are, however, showing increasing trends according to the Exiobase indicators, both when examining the consumption accounts (environmental impact of consumption in the EU) and production accounts (environmental impact of producing in the EU).

Figure 33: Particulate matter emissions of the agri-food industrial ecosystem (PM10, PM2.5) (in G Tons) - consumption account



Source: Technopolis Group based on Exiobase

[150] European Environmental Bureau (2024) Breaking free. Europe's animal welfare crises and the brighter future within reach. Retrieved from: https://eeb.org/wp-content/uploads/2024/05/EEB-Animal-Welfare-position-paper-final-web-version.pdf

[151] CAP dashboard (n.d.) Climate Change and Air Quality. Ammonia emissions from agriculture. Retrieved from: https://agridata.ec.europa.eu/extensions/DashboardIndicators/Climate.html

3. Digital transition

3.1. Industrial efforts into the digital transition

What is the progress of industrial efforts towards digitalisation?

- The share of digital related patenting activities in the industrial ecosystem lies **under the anticipated agri-food industrial ecosystem average** of 10%, with figures ranging between 2.5% and 5%. This can be explained by the fact that patents supporting the digital transition may be developed in other industrial ecosystems.

- **20% of companies had a concrete strategy in place for digital transformation** in the agri-food industrial ecosystem in 2024.

- **The EMI Enterprise Survey revealed an increase in the uptake of digital technologies like** Cloud, Internet of Things, Artificial Intelligence, and Robotics technologies. 73% of businesses that adopted AI did so within the past two years. **19% of companies use AI in the design and planning stage.** AI innovations are expected to **inform management decisions, improve efficiency, reduce waste, and enhance the overall sustainability** of the agri-food industrial ecosystem.

- **Startups active in the area of AI and big data lead the startup creation** with a total of 307 startups formed between 2015 and 2023.

- **The vast majority of agri-food companies invest less than 5% of their annual turnover into digital technologies**. A few select technologies are prioritized by companies investing more than 30% of their annual turnover, including in artificial intelligence (3.23%), IoT (5.41%) and robotics (12.5%).

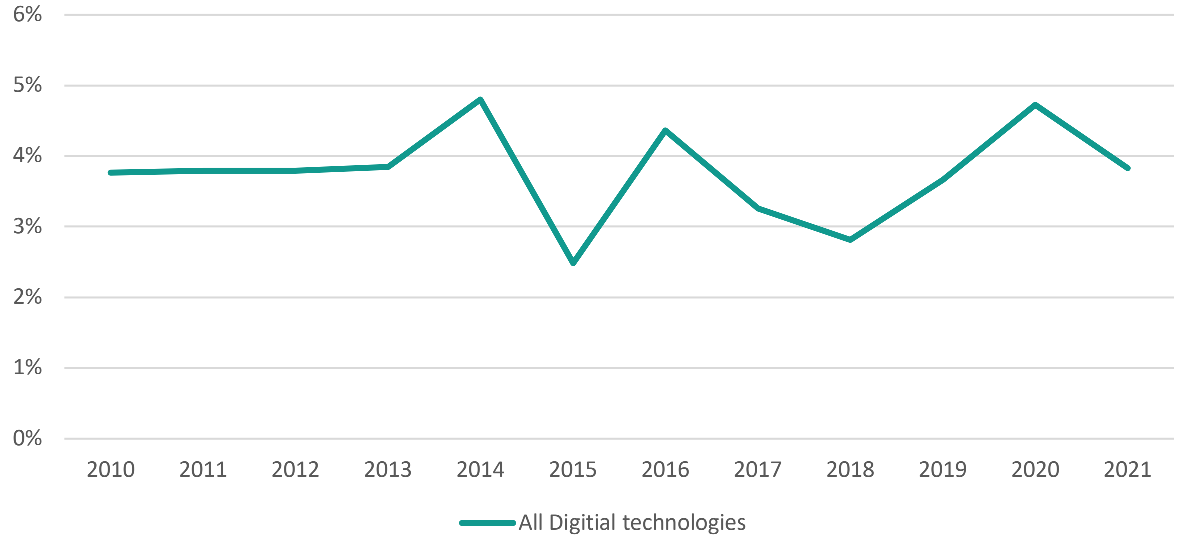
3.1.1. Technology generation

Technology generation in terms of patents for the digital transition[152] in the agri-food industrial ecosystem represent the complementary picture to those patenting activities highlighted under the green transition chapter above.

The share of digital transition-related patent activities of the agri-food industrial ecosystem relative to the other industrial ecosystems in the EU27 is presented in Figure 34. A volatile pattern emerges, with especially evident declines in patenting activities related to the digital transition in 2015 and 2018, as well as decreasing trend towards 2021. Overall, the share of digital related patenting activities in the industrial ecosystem lies under the anticipated industry average of 10%, with figures ranging between 2.5% and 5%. This can be explained by the fact that patents supporting the digital transition may be developed in other industrial ecosystems and applied to the agri-food industrial ecosystem, such as drones that are part of the mobility industrial ecosystem, or sensors which can be related to the electronics industrial ecosystem.

[152] Advanced digital technologies: advanced manufacturing and robotics, artificial intelligence and big data, augmented and virtual reality, blockchain, cloud computing, Internet of Things, digital security.

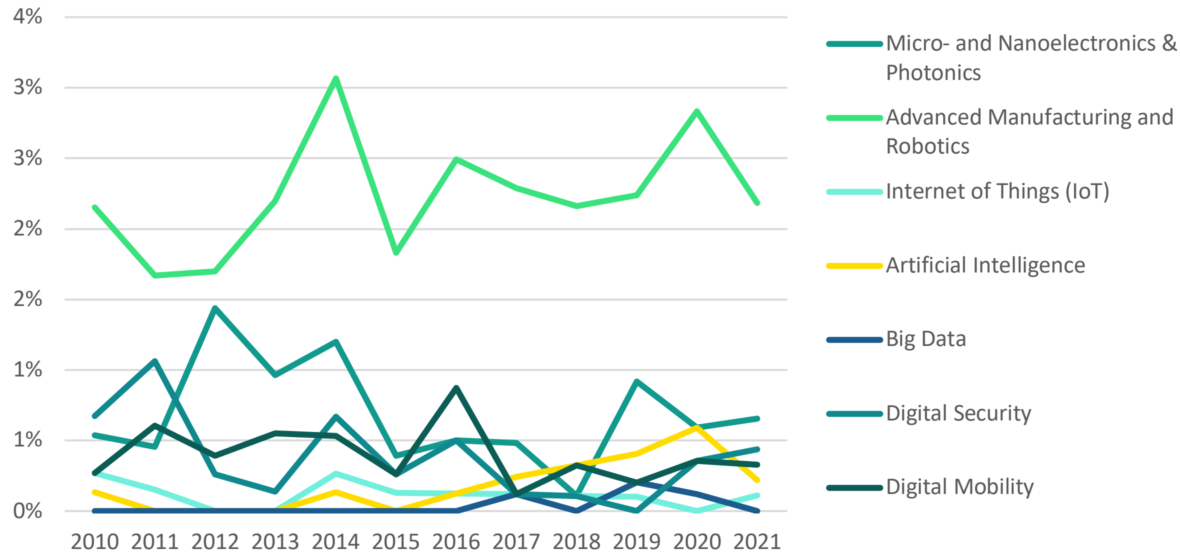
Figure 34: Share of digitalisation-related patents in the agri-food industrial ecosystem in all patents filed in EU27 industrial ecosystems



Source: Fraunhofer based on PATSTAT

For the digital technologies, advanced manufacturing technology and robotics, micro- and nanoelectronics and photonics (such as smart sensors) are the leading technologies according to patenting activities for the agri-food industrial ecosystems in terms of patenting activities over the period of 2010 to 2021 (see Figure 35). Recent years show the increasing importance of advanced manufacturing technology and robotics, artificial intelligence & big data and micro- and nanoelectronics and photonics in 2019 and 2020, with each making up 2.8%, 0.6% and 0.6%, respectively. A fall in 2021 can be observed that is likely related to the consequences of the COVID-19 pandemic.

Figure 35: Share of respective digital transition technologies in overall patents filed in the agri-food industrial ecosystem

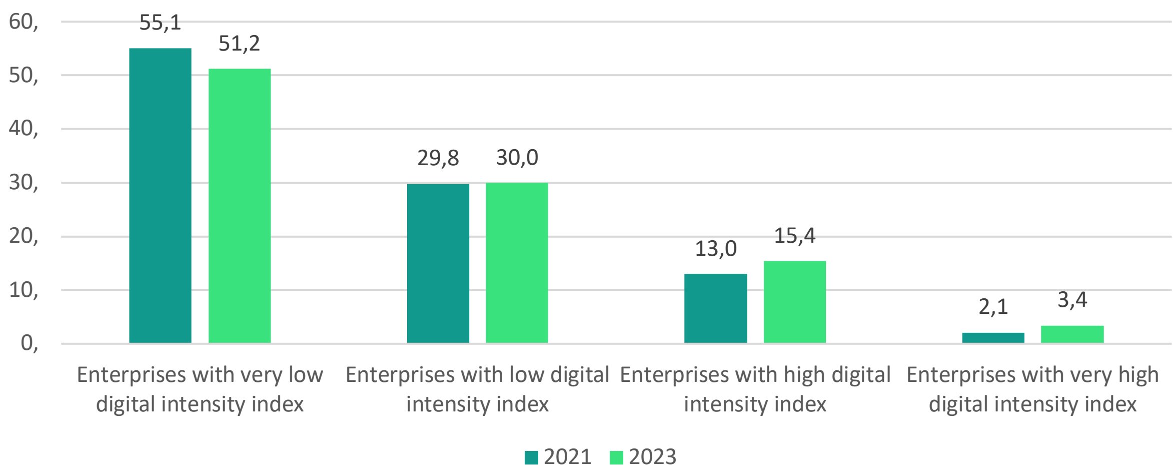


Source: Fraunhofer based on PATSTAT

3.1.2. Uptake of digital technologies

The targets of the Digital Compass set in relation to digital transformation of businesses are dedicated to help **late digital technology adopters** – more than 90% of SMEs to reach at least a basic level of digital intensity[153]. The digital intensity index captures information on the digital intensity of food manufacturing enterprises, however not agricultural enterprises. For the food manufacturing industry, there is a high share of enterprises with a very low digital intensity index, measured at 55% in 2021 and decreasing to 51% in 2023. Comparably, the number of enterprises with high digital intensity index and very high digital intensity index is on the rise with a roughly 2% increase for both over the same period pointing towards an increasing level of digitalisation (see Figure 36)[154].

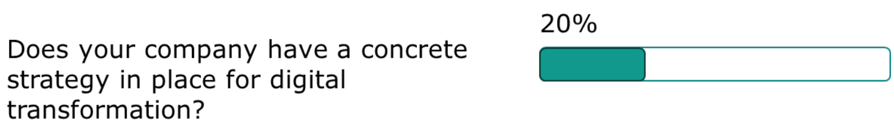
Figure 36: Digital intensity of food manufacturing enterprises[155]



Source: IDEA Consult based on Eurostat [isoc_e_diin2]

Despite these ambitious targets, according to the EMI survey 2024 results, **only 20% of companies have a concrete strategy in place for digital transformation in the agri-food industrial ecosystem** (see Figure 37).

Figure 37: Share of companies in the agri-food industrial ecosystem that has adopted a strategy for the digital transformation



Source: EMI Enterprise Survey 2024

In 2023, cloud and big data were the leading technologies, however in 2024 the landscape of digital technology adoption for the agri-food industrial ecosystem has shifted towards **Cloud, Internet of Things, Artificial Intelligence, and Robotics**, **as depicted in** Figure 38.

---

[153] European Commission (n.d.) Europe's Digital Decade: digital targets for 2030. Retrieved from: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_en

[154] Eurostat (2024). Digital Intensity by NACE Rev.2 activity. Retrieved from: https://ec.europa.eu/eurostat/databrowser/view/isoc_e_diin2__custom_13346345/default/table?lang=en

[155] Enterprises on agriculture not covered in the data set. Food manufacturing enterprises referring to NACE C 10-12 Manufacture of food products; beverages and tobacco products

Figure 38: Share of businesses in the agri-food industrial ecosystem that have adopted digital technologies

Digital Technologies	***Share of adoption (2023)***	***Share of adoption (2024)***	
Cloud	26%	37%	↑
Internet of Things	10%	24%	↑
Artificial Intelligence	11%	22%	↑
Robotics	11%	20%	
Big Data	17%	13%	
Edge Computing	3%	6%	
Blockchain	4%	5%	
Augmented and Virtual Reality	7%	3%	

Source: EMI Enterprise Survey 2024

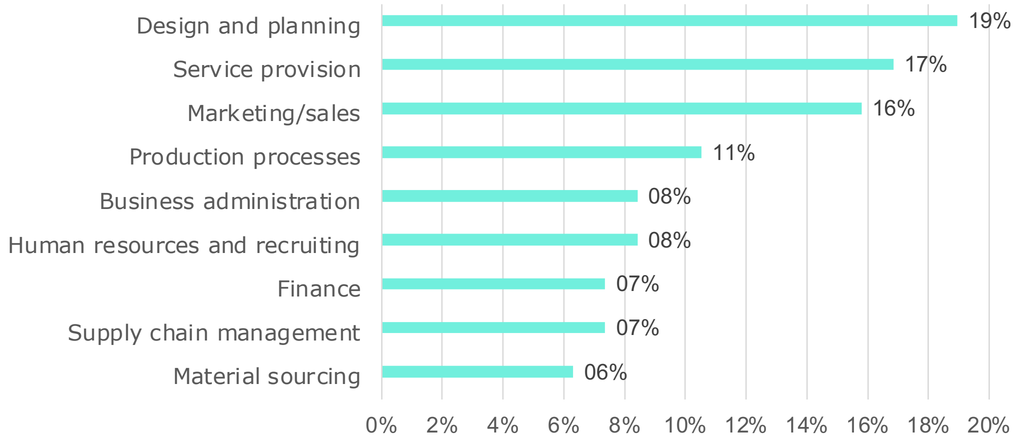
Note: edge computing were not covered in the previous survey. The comparison of values between 2024 and 2023 should be interpreted with caution, as there may be slight differences in the sample breakdown by ecosystem segment and refinements in the questions.

The following technologies are the priority digital technologies from within the methodological framework that have been identified to be of relevance for the agri-food industrial ecosystem. Other digital technologies supporting the digital transition also have their role to play but are not explicitly highlighted here. At the same time, it is important to mention the interplay between the green and digital transition, which is fully acknowledged: digital technologies are key for enabling the green transition, and the green transition spurs digital transition in finding new technologies to address the needs. That is also why these two form the so-called 'twin transition' together. For the purpose of the analysis and narrative these are explored separately, however specific examples addressing the green and digital transition are highlighted where possible.

Adoption of Artificial Intelligence

In particular, the growing volume of accessible data has the potential to significantly enhance the capability of AI algorithms. AI technology can offer innovative solutions ranging from predictive analytics and process optimisation to advanced procurement and consumer-tailored marketing strategies. The survey of companies in the agri-food industrial ecosystem indicates that **73% of businesses that have adopted AI have done so within the last two years**, with 13% having adopted this technology already for 5 years. In terms of business operation stage, 19% of companies use AI in the design and planning stage, as depicted in Figure 39 below. 45% of agri-food businesses use AI systems via external service providers, whereby 28% of businesses indicate that the AI used is provided by US service providers. Only 18% of companies develop their AI capabilities in-house.

Figure 39: Share of companies using AI according to the business operation stage



Source: EMI Enterprise Survey 2024, n=706

The use of big data and artificial intelligence (AI) in the agri-food industrial ecosystem is expanding and is having a significant impact on the food system[156]. AI technologies are being used for various applications, including precision farming, process optimisation, supply chain traceability, smart packaging and labelling, and personalised nutrition, among others. These innovations are expected to inform management decisions, improve efficiency, reduce waste, and enhance the overall sustainability of the agri-food industrial ecosystem.

For example, the AI Pathfinder project aims to enhance the adoption of AI applications in the food industry. It explores, based on the needs and challenges of food companies, how AI can add value and how machine builders, technology providers and food companies can successfully collaborate to facilitate future AI projects[157].

Furthermore, AI is anticipated to unlock insights that could help reduce global greenhouse gas (GHG) emissions by 5% to 10% by 2030[158]. This will be achieved through the scaling of proven applications and the enhancement of climate-related adaptation and resilience initiatives.

Advanced manufacturing technology and robotics

In the agricultural sector, the shortage of farm labour presents a major challenge for farmers. To tackle this problem, agricultural startups and large companies are developing robotics solutions to assist in carrying out various tasks such as fruit picking, planting, transplanting, harvesting, seeding, spraying, and weeding. By automating repetitive field chores, these agricultural robots are transforming farm work. Farmers are also adopting advanced agricultural machinery, such as autonomous and semi-autonomous tractors with auto-steer technology, to enhance harvesting and navigation efficiency[159]. Projections show that by 2025, half of northwest European dairy farms will be robotically milked, up from one fourth in 2015[160].

Advanced manufacturing technology and robots are increasingly used in the food industry thanks to their ability to enhance efficiency, consistency, and hygiene. The food robotics market (including picking, processing, packing, palletising) was valued at EUR 1.8 bn in

[156] EIT Food (2024) Top 5 food trends in 2024. Retrieved from: https://www.eitfood.eu/blog/top-5-food-trends-in-2024
[157] https://www.sirris.be/en/joint-project/ai-pathfinder-adoption-ai-applications-food-industry
[158] EIT Food (2024) Top 5 food trends in 2024. https://www.eitfood.eu/blog/top-5-food-trends-in-2024
[159] StartUs Insights (2024). Uncover the Top 10 Agriculture Trends, Technologies & Innovations in 2025. Retrieved from: https://www.startus-insights.com/innovators-guide/agriculture-trends-innovation/
[160] OECD (2022) The Digitalisation of Agriculture: A Literature Review and Emerging Policy Issues. Retrieved from: https://www.oecd.org/en/publications/2022/04/the-digitalisation-of-agriculture_dd2a1973.html

2020 and is estimated to reach EUR 5.2[161]. In food processing and packaging, robots perform repetitive tasks with precision. They speed up processes such as sorting, packaging, and assembly line work, leading to increased productivity. Additionally, robots improve hygiene and safety by minimising human contact with food products, which reduces the risk of contamination[162].

Internet of Things

Internet of Things (IoT) technologies allow to provide real time insights into farming and production activities, with the aim of increasing yield, as well as to improve the storage and disposal of food through enhanced information provision. Markets and Markets estimate that the global agriculture IoT market will grow from EUR 10.3 bn in 2021 to EUR 16.4 bn[163] in 2026. According to Market Research Wire, the European agriculture IoT market accounted for EUR 3.12 bn in 2019 and will grow by 12.4% annually over 2020-2030[164].

The drivers for this growth are the increased adoption of variable rate technology, remote sensing and guidance technologies by farmers worldwide. Variable rate technology allows for precise application of fertiliser, agricultural chemicals, irrigation, among others, allowing for optimised resource inputs based on the specific needs[165]. Remote sensing allows to monitor agricultural production on fields getting more insights into e.g. growth height, plant development without necessarily intervening in the field. Guidance technologies facilitate the application of e.g. robotics to support agricultural activities, in the field but also in greenhouses, further enabling their uptake.

In precision agriculture, internet of things (IoT) analytics of data from connected equipment can help farmers analyse real-time data like weather, temperature, moisture, prices or global positioning system (GPS) signals and provide insights on how to optimise and increase yield[166].This should improve farm planning and help farmers make decisions about the level of resources needed, for example to optimise water use for crops and support the development of irrigation schedules and water stress monitoring.

Notably, the uptake of precision technology in dairy farming in several countries is significant, with widespread use of tools and apps for managing operations[167].

The uptake of Internet of Things in food industry relies largely on the application of smart solutions and their connectivity. The applications vary from uses in optimising food processes, predicting maintenance, but also ensuring the highest healthy and safety standards are applied, while at the same time offering the opportunity to communicate towards end consumers. The interlinkages between IoT and other digital technologies lie especially in relation to AI and big data, to support decision making and efficiency gains, but also advanced manufacturing technologies and robotics, as well as blockchain[168].

[161] Allied Market Research (2022) Food Robotics Market Size, Share, Competitive Landscape and Trend Analysis Report Retrieved from: https://www.alliedmarketresearch.com/food-robotics-market#:~:text=Food%20robotics%20market%20was%20valued,picking%2C%20packing%2C%20and%20palletizing
[162] Foodics (2025) Retrieved from: https://www.foodics.com/robotics-in-the-food-industry/
[163] Markets and Markets (2021) Agriculture IoT market. Retrieved from: https://www.marketsandmarkets.com/Market-Reports/iot-in-agriculture-market-199564903.html
[164] Market Research Wire (2025) Europe Agriculture IoT Market. Retrieved from: https://marketresearchwire.com/europe-agriculture-iot-market/
[165] EOS Data Analytics (2024) Variable Rate Technology: What is this and how it works. Retrieved from: https://eos.com/blog/variable-rate-technology/
[166] European Parliament (2023) Artificial intelligence in the agri-food sector. Retrieved from: https://www.europarl.europa.eu/stoa/en/document/EPRS_STU(2023)734711
[167] OECD (2022) The Digitalisation of Agriculture: A Literature Review and Emerging Policy Issues. Retrieved from: https://www.oecd.org/en/publications/2022/04/the-digitalisation-of-agriculture_dd2a1973.html
[168] Dadhaneeya, H et al. (2023) Internet of Things in food processing and its potential in Industry 4.0 era: A review, Trends in Food Science & Technology, Volume 139 (2023), 104109, retrieved from: https://doi.org/10.1016/j.tifs.2023.07.006

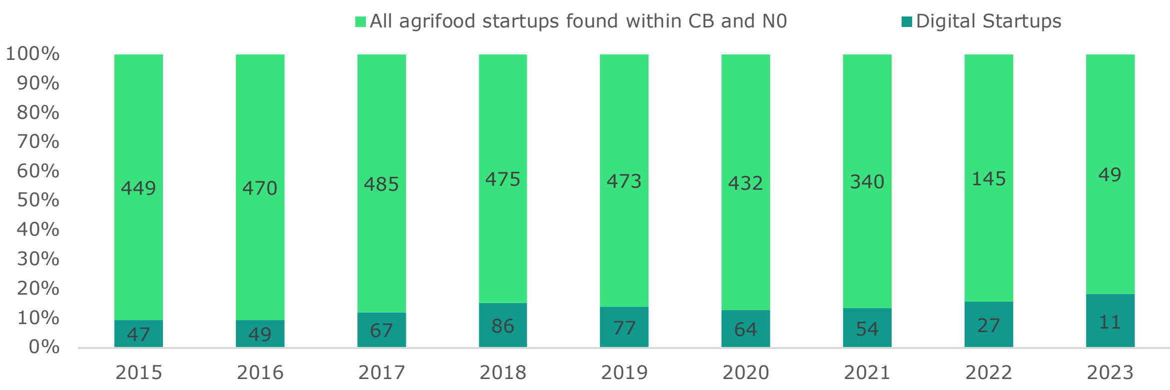
Blockchain

Blockchain represents a specific technological solution that allows for distribution of information that supports supply chain activities, building trust among stakeholders including also consumers, enabling overall transparency in the agri-food industrial ecosystem. The key features of blockchain as a technology make it interesting for the agri-food industrial ecosystem as it can be considered reliable and safe for all users in an otherwise complex landscape of information exchange. The decision whether or not blockchain remains interesting for the agri-food industrial ecosystem depends also on the needs of the supply chain actors, differing for processors, distributors, retailers, and consumers, among others. Operational elements may aid or hinder the uptake of blockchain, such as internet connectivity, digital literacy, and the availability of related digital infrastructure. The design and uptake of blockchain are still based on the use of best practice examples, with no one-size-fits-all solution available to date[169].

3.1.3. Digital tech startups venturing in agri-food

A **total of 482 digital transition related startups** were created in relation to the agri-food industrial ecosystem between 2014 and 2023 according to the Crunchbase and Net Zero Insights dataset compiled for this study.

Figure 40: Startups related to the digital transition in the agri-food industrial ecosystem



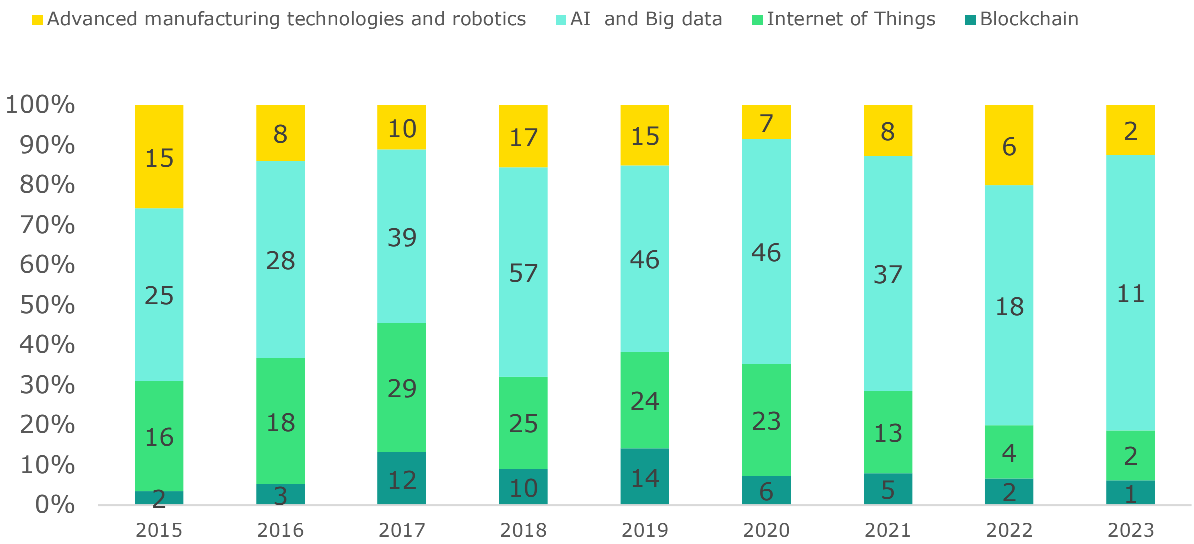
Source: Technopolis Group based on Crunchbase and Net Zero Insights

Figure 41 presents the normalised number of startups created in digital technologies over the period 2015 to 2023. A normalised figure is presented as a data lag affects the later years (2019 onwards) with especially 2023 showing low figures on startup creation related to the digital transition (total N=16 in 2023 versus N=109 in 2018) allowing to relativize the information presented[170]. Startups active in the area of AI and big data lead the startup creation for the agri-food industrial ecosystem with a total of 307 startups formed between 2015 and 2023. This is followed by start-ups active in Internet of Things with 154 startups formed related to this technology over the same period.

[169] UNDP (2021) Blockchain for agri-food traceability. Retrieved from: https://www.undp.org/publications/blockchain-agri-food-traceability

[170] The inclusion of newly created companies in Crunchbase databases is subject to a lag, as startups typically do not have an online presence until their second or third year. As a result, data on the most recent years may be incomplete.

Figure 41: Technologies underpinning digital tech startups in the agri-food industrial ecosystem



Source: Technopolis Group based on Crunchbase and NO

Examples showcasing some of the digital technologies the startups cover include:

- **Augmenta** (AI and big data) founded in 2016, focuses on delivering an AI-based solution to support in obtaining maximum efficiency for farmers in support of increasing seasonal net income[171] [172].
- **Sensoterra** (Internet of things) founded in 2015, is active in the area of developing wireless, low-cost sensors to detect moisture levels in support of irrigation and water management [173] [174].
- **Agrointelli** (Advanced manufacturing technology and robotics) founded in 2015 under the name Agri Intelligence aims at developing autonomous solutions to support field work in agriculture [175] [176].

Startups also receive support among others through EIT Food. **Microfy.AI** was declared a startup to watch[177] by EIT Food and was founded in 2019. Box 3 highlights further details about the company, that focuses on the use of smart microscopy for quality control in the food sector with applications in the use of artificial intelligence to honey production, among others. In 2023, the startup, **Ant Robotics**[178] (Germany was chosen as one of the companies to participate in the EIT Food Accelerator Network[179]. It has created product that supports workers during the harvest of fruits and vegetables, reducing non-productive time spent on transporting crates based on robotics.

[171] https://www.eu-startups.com/directory/augmenta/
[172] https://www.ravenind.com/products/applications-booms/augmenta-field-analyzer
[173] https://www.crunchbase.com/organization/sensoterra
[174] https://www.sensoterra.com/
[175] https://agrointelli.com/
[176] https://www.crunchbase.com/organization/agro-intelligence
[177] EIT Food (2024) 10 agrifood startups to watch in 2024. Retrieved from: https://www.eitfood.eu/news/10-agri-food-startups-to-watch-in-2024
[178] https://www.antrobotics.de/
[179] https://www.eitfood.eu/entrepreneurship/accelerate-food-accelerator-network

Box 3: Example startup – Microfy.AI

Microfy.AI: AI-powered honey analysis

Microfy.AI[180] produces AI-powered microscopes for assessing the quality of honey. The technology can produce fast results *in situ* by honey producers, who currently rely on external labs which use a variety of methods that can be hard to reproduce.

In 2023, the first microscope 'Honey.AI' was launched to the market and the company already has customers across nine countries, including the Spanish government. Based in Barcelona, Microfy.AI has received extensive media coverage and was a recipient of the 2023 CERES awards[181] hosted by EIT Food South.

Microfy.AI is now developing a tool capable of detecting a specific disease in beehives, which can help beekeepers to reduce bee mortality rates. The company is also developing prototypes for applying the technology to other applications – such as monitoring yeast and fungi growth.

Source: Microfy.AI, 2024

3.1.4. Private investments

Investments play a central role in digitising the agri-food industrial ecosystem. However, EU companies tend to structurally invest low volumes into digital technologies.

The findings from the EMI survey as presented in Figure 42 below indicates that the share of respondents who indicated to make investments in advanced digital technologies in the agri-food industrial ecosystem remains low. The majority of respondents indicate that less than 1% of annual turnover in digital technologies, and the vast majority of companies invest less than 5% of annual turnover in the same digital technologies. A few select technologies are prioritized by companies investing more than 30% of their annual turnover, including in artificial intelligence (3.23%), IoT (5.41%) and robotics (12.5%).

Figure 42: Level of investment of businesses in agri-food into digital technologies

	Cloud	Robotics	IoT	Big Data	AI	AVR	Blockchain
Less than 1% of annual turnover	46%	20%	49%	59%	84%	50%	29%
1-5% of annual turnover	44%	19%	22%	18%	3%	17%	29%
6-10% of annual turnover	7%	6%	5%			4%	
11-30% of annual turnover	3%		7%	4%			14%
More than 30% of annual turnover		12%	5%		3%		

Source: EMI Enterprise Survey 2024

Globally, the food and agriculture technology market was **severely hit by the venture capital downturn** in 2023. Specifically, the annual investment report of the global agri-food tech sector[182] indicates that **investments in agri-food tech startups were at its lowest point in six years in 2023**. These investments have been declining since 2021, which was an outstandingly successful year. In total, agri-food tech startups raised EUR 14.2 bn globally in 2023, **down to 49.2% percent** from EUR 27.7 bn in 2022.

[180] https://honey-ai.com/es/homeHi
[181] https://www.eitfood.eu/projects/the-1st-edition-of-ceres-awards-by-eit-food-south-is-here-3
[182] AgFunder (2024) Global AgriFoodTech Investment Report 2024. Retrieved from: https://agfunder.com/research/agfunder-global-agrifoodtech-investment-report-2024/

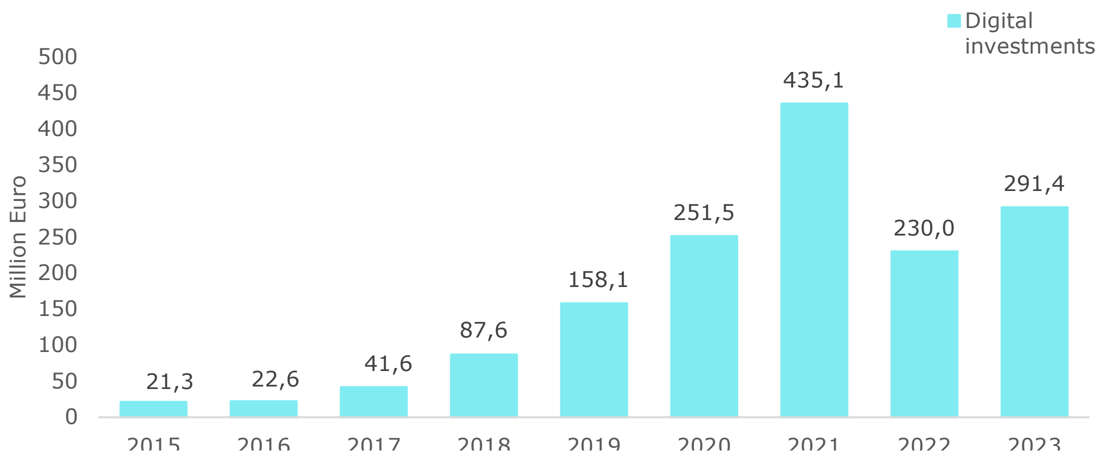
Furthermore, in 2023, agri-food tech represented just 5.5% of all venture capital sector dollars, down from 6.7% in 2022 and 7.6% in 2021. Nevertheless, the report underlines differences along categories of agri-food tech startups. Funding to all agri-food tech categories declined, expect for funding to 'Bioenergy & Biomaterials' and 'Farm Robotics, Mechanisation & Equipment'. In general, Bioenergy & Biomaterials was the largest category, generating EUR 2.7 bn in 2023, a 20% increase from 2022. Investments in Farm Robotics, Mechanisation & Equipment continued the steady upward trajectory it has known for the past five years, increasing 9% year-over-year to EUR 692 million. In general, the second largest investments were in the categories of Ag Biotechnology (which however lost 34% year-over-year)[183].

In addition, it is important to note that there were regional differences, with **Europe being least hit by the downturn, with a 14% year-over-year decline in funding**. In total, however, North and South America still invest most in agri-food tech (39.4%), followed by Europe (32.9%) and Asia (24.5%)[184]. The unmet demand of farmers for financing by banks has reached EUR 62 bn in 2022, according to two surveys presented by former Commissioner Wojciechowski at the 9th annual EU conference on European Agricultural Fund for Rural Development (EAFRD)-funded financial instruments[185]. Small farms and young farmers are being most affected by this lack of loans and financial investments.

A Crunchbase and Net Zero Insights data set gives insight into venture capital investments in young companies (age 10 years or less) and gives insights into the amount of investment related to the broader digital transition as well as the investments related to the technologies underpinning the transition, notably AI and big data, internet of things, advanced manufacturing technology and robotics as well as blockchain. The data set contains some data lags for the most recent year (2023) however venture capital data remain sufficiently well reported so general trends can be observed.

Venture capital investments in the agri-food industrial ecosystem related to the digital transition peaked in 2021 at EUR 431.5 million. While the results align broadly with the trends reported, with a general downturn from 2021, the data reported for 2022 and 2023 differ. 2022 shows lower overall venture capital investment sums than 2023, hinting at a potential upward trend, which could be explained by the fact that Europe was less impacted by the venture capital investment downturn after 2021 than the rest of the world.

Figure 43: Venture capital investment into agri-food young companies in the EU27 – digital transition



Source: Technopolis Group based on Crunchbase and Net Zero Insights

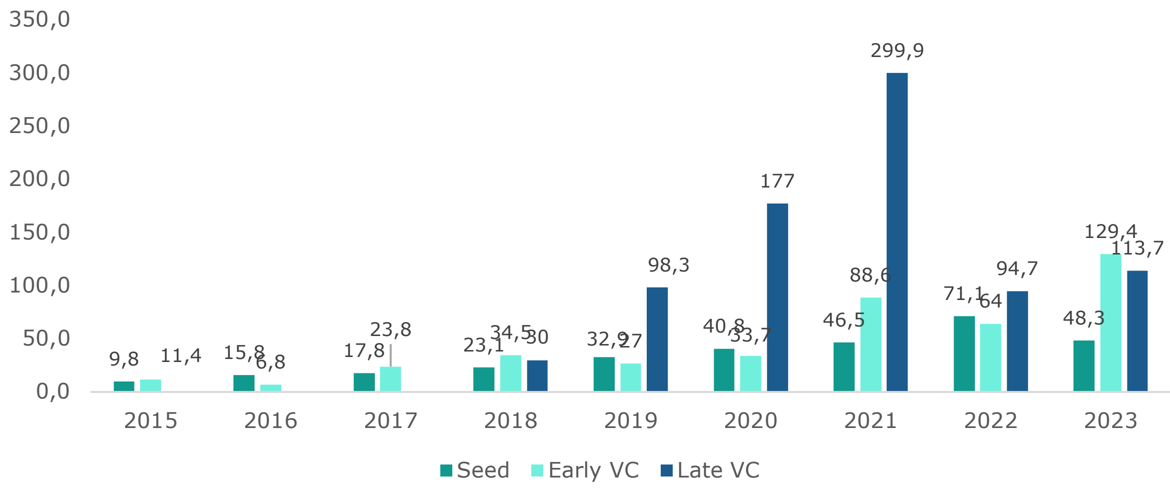
183 AgFunder (2024) Global AgriFoodTech Investment Report 2024. Retrieved from: https://agfunder.com/research/agfunder-global-agrifoodtech-investment-report-2024/

184 AgFunder (2024) Global AgriFoodTech Investment Report 2024. Retrieved from: https://agfunder.com/research/agfunder-global-agrifoodtech-investment-report-2024/

185 Fi-Compass (n.d.) About the Conference. Retrieved from: https://events.fi-compass.eu/event/4d8fc430-27e2-4e2c-859d-c9eaefdd71e0/summary

In terms of the venture capital investment stages in the digital transition of agri-food startups, Figure 44 presents these according to seed, early venture capital (VC) and late VC. It is apparent that the digital transition is largely dominated by late VC investment, however especially in 2023, early VC investment has become more important, possibly as a consequence of the VC downturn.

Figure 44: Venture capital investments stages into digital transition of agri-food startups in the EU27



Source: Technopolis Group based on Crunchbase and Net Zero Insights

Investments related to the technologies AI and big data, internet of things, advanced manufacturing technology and robotics, as well as blockchain show differing trends in relation to the overall downturn from 2022 onwards. Notably, AI and big data as well as internet of things were impacted by the downturn in 2022 and 2023, with advanced manufacturing technology and robotics experienced an upturn in 2023 especially, though orders of magnitude are different.

Details on the funding rounds of select young companies based on the Crunchbase and NetZero Insights dataset include:

- **Augmenta** (AI and big data) has raised a total of EUR 112.3 million in funding over five rounds. Augmenta was acquired in 2023 by CNH Industria.
- **Sensoterra** (Internet of things) has raised a total of EUR 2.9 million in funding over two rounds, with the last funding being raised in 2022.
- **Agrointelli** (Advanced manufacturing technology and robotics) has raised a total of EUR 16.8 million in funding over four rounds. Their latest funding was raised in 2023 from a late VC round.

3.2. Framework conditions – assessment of the broader ecosystem supporting the digital transition

To what extent do framework conditions such as public financing and skills support the digital transition?

- The European Regional Development Fund (ERDF) plays a vital role in the digital transition of the agri-food industrial ecosystem. Over the period 2014-2020, **about 10% (or EUR 1.59 bn) of the funding to agri-food ERDF projects supported the digital transition.**

- **26.1% of the EC H2020 funding to agri-food projects contributed to the digital transition**. In Horizon Europe 18.1% of the EC funding to date contributes to agri-food projects related to the digital transition.

- In 2024, **2% of professionals registered on LinkedIn and employed within the agri-food industrial ecosystem possessed advanced digital skills and 15.1% possessed other more moderate digital skills, marking an increase from the levels observed in 2022**. This suggests progress in the overall digital competency, while the adoption of more advanced digital expertise has yet to experience significant growth.

- **Requirements for digital skills listed on online job advertisements within agri-food has been growing** over the period from 2019-2023. 12% of the job advertisements included a requirement of advanced digital skill such as **AI, big data, augmented and virtual reality, cloud**, compared to 25% of the job advertisements requiring moderate digital skills.

3.2.1. Public investments supporting the digital transition

This study examines the **public investments supporting the digital transition in the agri-food industrial ecosystem.** The public investment sources analysed are the Cohesion policy, and in particular the European Regional Development Fund (ERDF), and the Framework Programmes, Horizon 2020 and Horizon Europe.

Cohesion policy

A key source of public funding that enables the digital transition is the **EU's regional development funds**. For this analysis, two data sources have been used and merged, namely the Cohesion Open Data maintained by the European Commission and the Kohesio data[186].

ERDF projects[187] that are related to the agri-food industrial ecosystem could be identified in the data[188]. As mentioned in Section 2.2.1, the total number of **ERDF projects in the agri-food industrial ecosystem** that could be identified in 2014-2020 was 26 873, representing a total funding of EUR 15.25 bn. The analysis shows that **about 10%** (or EUR 1.59 bn) **of the funding to agri-food ERDF projects supported the digital transition**. An example of an ERDF agri-food project supporting the digital transition is in Box 4.

[186] For more information on the data sources and the approach, see the methodological report.

[187] The European Regional Development Fund (ERDF) supports projects aimed to strengthen economic, social and territorial cohesion in the European Union. It aims to correct imbalances between regions enabling investments in a smarter, greener, more connected and more social Europe that is closer to its citizens. The ERDF finances programmes in shared responsibility between the European Commission and national and regional authorities in Member States.

[188] Based on the codes of economic activity and additional keyword searches in the project descriptions.

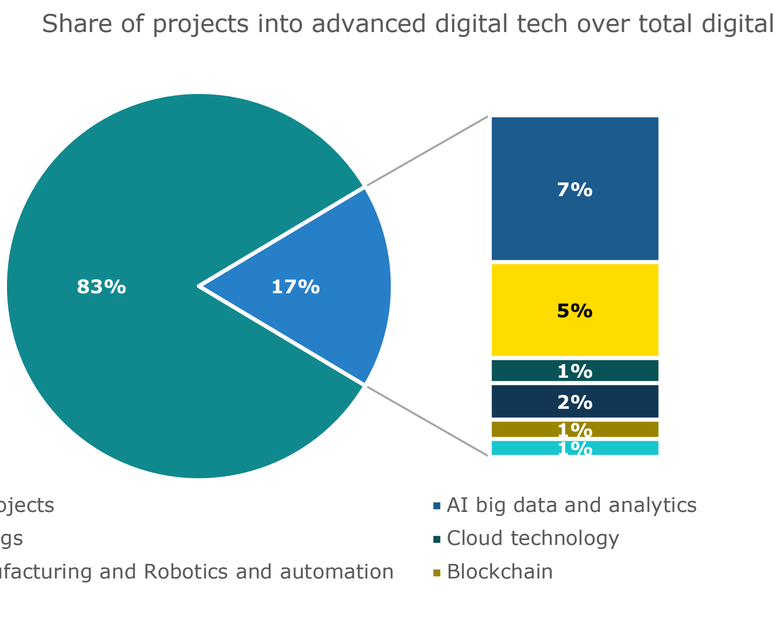
Box 4. ERDF agri-food projects supporting the digital transition

Hungary developed a project titled "**Development of variants of dairy products with proven health-protection effect based on robotic, precision-driven food raw material production using unique active ingredient combinations and innovative technologies**" from 2019 to 2022, funded by the EU with a budget of EUR 3,755,542.08. The project focuses on high-quality and health-promoting dairy products based on domestic agroecological conditions. To achieve this, it involves developing and implementing breeding techniques to support precision milk production (bovine farming). The goal is to introduce dairy products that are not found on the market or have biological values that match modern dietary trends and health-conscious dietary needs. The project addresses the increasing frequency of nutrition-related diseases such as Crohn's, diabetes, and irritable bowel syndrome.

Source: The authors based on Kohesio

Furthermore, when examining the ERDF agri-food projects that contribute to the digital transition, 17% of the funding in these projects is going towards projects related to advanced digital technologies[189] and 83% are hence other digital projects (see Figure 45). Most of these projects are related to AI, big data and analytics, followed by IoT.

Figure 45: Share of funding contributing to the digital transition in the agri-food industrial ecosystem by category (2014-2020)



Source: Technopolis Group based on Kohesio

Framework Programmes

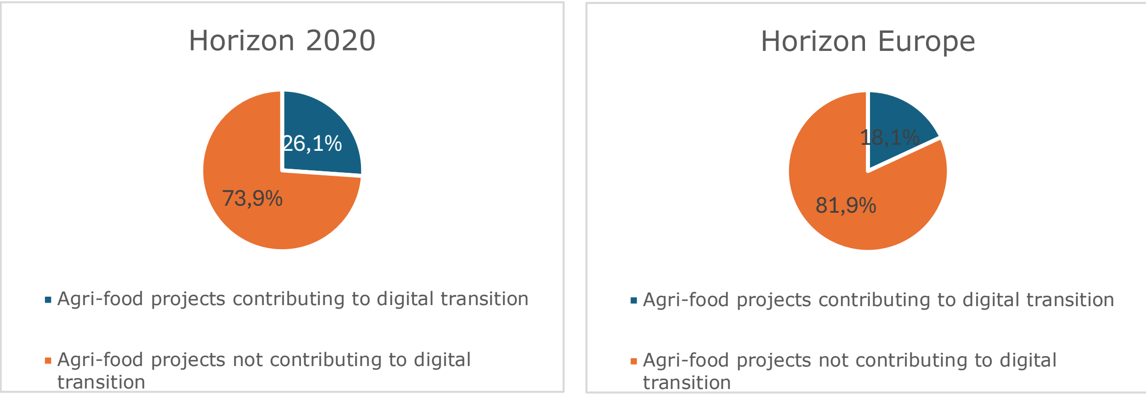
In this study, funding data from the EC Framework Programmes for Research and Innovation, in particular from Horizon 2020 (2014-2020) and Horizon Europe (2021-2027) was further analysed. As outlined in Chapter 2.2.1, the analysis of the CORDIS data demonstrates that the Horizon 2020 programme provided EUR 1.3 bn to projects classified

[189] As identified for the purpose of this project, e.g., projects related to IoT, AI, Cloud, Blockchain, advanced manufacturing etc.

under the agri-food industrial ecosystem[190]. Horizon Europe thus far[191] provided EUR 670.3 million to those projects.

In Horizon 2020, **26.1% of the EC funding to agri-food projects contributed to the digital transition**. In Horizon Europe **18.1% of the EC funding** to date contributes to agri-food projects related to the digital transition. This trend could be related to the increasing importance of the European Green Deal and hence increasing the tendency towards more green projects versus digital projects. It is to be noted that there are of course Framework Programme projects that contribute to both the green and digital transition.

Figure 46: Share of Horizon 2020 and Horizon Europe agri-food projects that contribute to the digital transition



Source: Technopolis Group based on CORDIS

Several examples of agri-food projects funded under Horizon 2020 and Horizon Europe supporting the digital transition are described in Box 5.

Box 5. Horizon 2020 and Horizon Europe agri-food projects supporting the green transition

AFarCloud[192] is a Horizon 2020 project that started in 2018, ended in 2021, and received an EC contribution of EUR 8.19 million. AFarCloud has developed a **distributed platform for autonomous farming** that enables the integration of agriculture intelligent systems in real time with the objective to lower labour costs while increasing production, efficiency, animal health, and food quality. This platform is integrated with farm management software and would eventually enhance productivity, food quality, crop and livestock health, and reduce labour costs. In addition, the project also aimed to provide more farmers with access to farming robots by establishing a cooperative network of farming vehicles. The AFarCloud project has achieved several milestones, including the development of a smart farming platform for monitoring crops and livestock, managing autonomous vehicles like drones and tractors, and the creation of a secure communication infrastructure. It implemented cloud-based middleware for real-time mission management and security mechanisms such as blockchain and secure updates for sensors.

The project introduced methodologies for automating agricultural tasks and integrated various hardware and software systems for autonomous operations. It also developed sensors and AI algorithms for soil, crop, and livestock monitoring, along with drones for real-time data collection.

AGRARSENSE[193] is a Horizon Europe project that started in 2023 and receives an EC contribution of EUR 14.3 million. The AGRARSENSE project goal is to create a holistic ecosystem of sensory and automated capabilities to further extend Europe's lead in optimizing and securing agricultural value chains. In practice, AGRARSENSE will develop several technologies such as **automated farming tools and improved sensor technology**. The AGRARSENSE project has developed

[190] The methodological report provides detailed insights into the methodology. In particular, the CORDIS data have been merged with the relevant EuroSciVoc data. EuroSciVoc connects projects to relevant scientific concepts, providing a deeper understanding of the research focus.

[191] Cut-off date is March 2024

[192] European Commission (n.d.) CORDIS – Aggregate Farming in the Cloud. Retrieved from: https://cordis.europa.eu/project/id/783221

[193] European Commission (n.d.) Smart, digitalised components and systems for data-based agriculture and Forestry. Retrieved from: https://cordis.europa.eu/project/id/101095835

several use cases to enhance agricultural practices. For example, in the vertical farming use case, the focus is on creating a more productive farming system through AI and advanced sensor technology, aiming to reduce fertilizer and water consumption while lowering CO_2 emissions with improved LED panels. Another notable example is the use case on precision viticulture, which seeks to increase both the quantity and quality of grape yields while minimizing pesticide use. This is achieved by optimizing irrigation and fertilization based on plant needs and integrating various data sources for predictive decision-making. Lastly, in the agri-robotics use case, a highly automated vineyard robot platform is being developed, enabling wine growers to manage their vineyards remotely in real time and enhancing early disease detection through improved sensor technology.

Source: CORDIS

3.2.2. Skills underpinning the digital transition

The agri-food industrial ecosystem needs human resources in all different subsectors and faces specific skills-related shortages. For instance, it increasingly requires highly skilled workers, such as agronomists, machinery and contact material specialists, circular and biotech experts, veterinarians, and food scientists in different subsectors[194]. Furthermore, there are concerns in the ecosystem regarding generational renewal and attracting talent, mainly in agriculture, but also in the food industry and food services[195].

The transition pathway outlines some primary skills gaps, and points to, amongst others, digital skills, innovative solutions skills, food quality management skills. There is also a mismatch in existing curricula and real-life industry requirements[196]. Keeping up with the latest technological and wider developments in agri-food requires changes in vocational education and training (VET) programmes, curricula, and delivery to build in the capacity to adjust to changing skill needs and upscaling the use of supportive ICT tools[197]. The sector's challenges require a multidisciplinary approach, increasing the demand for STEM qualifications, particularly in biology, biochemistry, chemistry, engineering, and IT skills for Farming 4.0 and continuous flow processes in food manufacturing. In addition, VET should place equal importance on training young workers about to enter the labour market and up- and reskilling adults.

To provide insights into the skills demand and skills supply in the agri-food industrial ecosystem related to the digital transition, this study builds upon two exploratory data sources, namely the Cedefop Skills-OVATE database and LinkedIn respectively[198]. The following definitions have been adopted:

Moderate digital skills have been defined following Cedefop[199] notably including "*five types of skills under the digital skills umbrella such as information processing (e.g. using a search engine and storing information and data); communication (including teleconferencing and application sharing); content creation (such as producing text and tables, and multimedia content); security (e.g. using a password and encrypting files); and, problem solving (e.g. finding IT assistance and using software tools to solve problems)*". (The list of keywords that have been used to track LinkedIn is included in Appendix B).

Advanced digital skills have been defined as a specific group of digital skills in the context of the advanced digital technologies captured in this project notably in artificial intelligence, big data, cloud computing, robotics, Internet of Things, digital security,

---

[194] European Commission (2024). Transition pathway for the agri-food industrial ecosystem
[195] European Commission (2024). Transition pathway for the agri-food industrial ecosystem
[196] European Commission (2024). Transition pathway for the agri-food industrial ecosystem
[197] Cedefop (2023) Growing green: how vocational education and training can drive the green transition in agri-food. Luxembourg: Publications Office. Policy brief. Retrieved from: http://data.europa.eu/doi/10.2801/305793
[198] More information on the data sources, the approach taken, and the limitations of the data, is found in the methodological report.
[199] https://www.cedefop.europa.eu/en/data-insights/digital-skills-challenges-and-opportunities

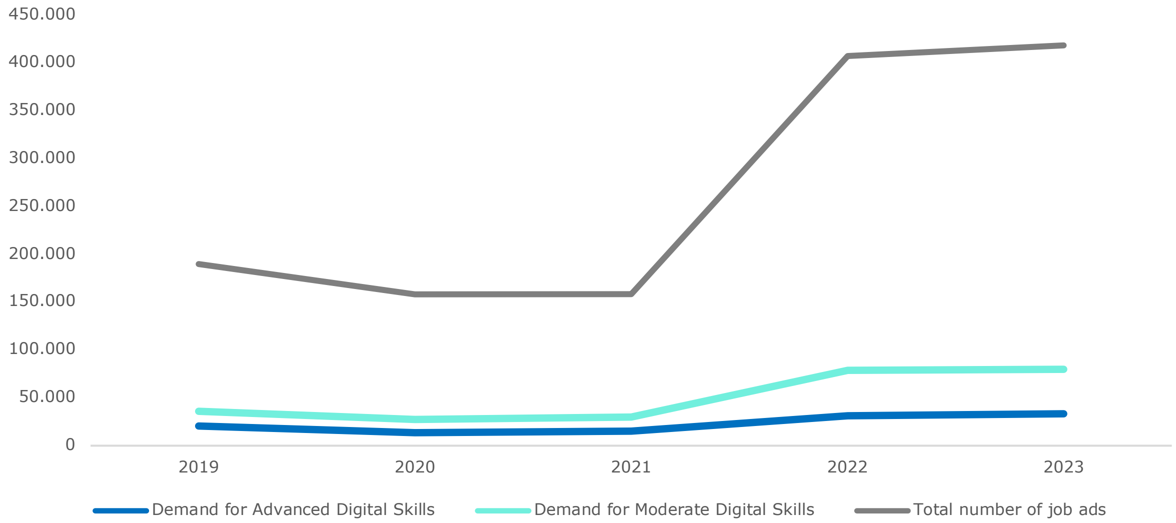
augmented and virtual reality and blockchain (the list of keywords that have been used and are possible to track with the algorithm of LinkedIn is included in Appendix B).

Skills demand

Skills demand in the agri-food industrial ecosystem has been analysed following the skills intelligence insights of Cedefop, as outlined in Chapter 2. These data provide insights into the job advertisements in the agri-food industrial ecosystem and about the advanced and moderate digital skills that are in demand.

The results indicate that the requirements for digital skills listed on online job advertisements within agri-food has been growing over the period from 2019-2023. The total number of online job advertisements in agri-food amounted to 418 128 in 2023 in the EU27. The results of the data analysis show that 12% of the job ads included a requirement of advanced digital skill such as AI, big data, augmented and virtual reality, cloud. A higher share notably 25% of the job ads required moderate digital skills (more than simple Microsoft or web skills but not necessarily artificial intelligence).

Figure 47: Share of online job advertisements with a requirement for digital skills in agri-food in the EU27



Source: Technopolis Group based on analysis of Cedefop data

Skills supply

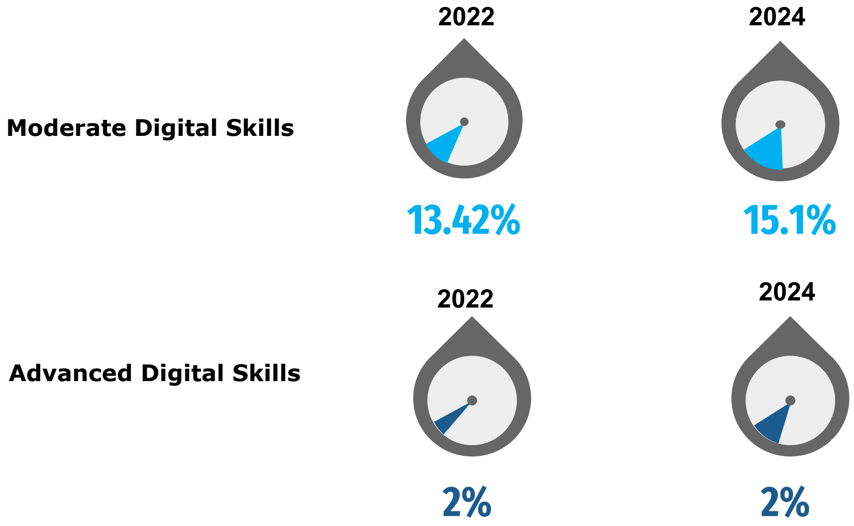
As described in Chapter 2, the LinkedIn database has been consulted to gain insights into professionals working in the agri-food industrial ecosystem. Keywords have been defined to capture the advanced digital transition skills that professionals have. In particular, advanced digital skills have been again defined as artificial intelligence, cloud computing, big data, robotics, Internet of Things, augmented and virtual reality, digital security and blockchain, but advanced software technologies have been also included that are relevant for the industrial ecosystem (such as farm management software).

As outlined earlier, there were 4.17 million professionals registered in agri-food on LinkedIn in April 2024 of which 1.4 million professionals were in 'food manufacturing' specifically. In our assessment this represents around 25.4% of food manufacturing professionals active on LinkedIn. Along the same lines, several subpopulations are underrepresented in the data, such as professionals in agriculture.

The results show that the share of professionals with moderate digital skills has grown between 2022 and 2024, reaching 15.1% in 2024. However, the share of professionals with advanced digital skills has remained stable over the same period. This suggests progress in the overall digital competency, while the adoption of more advanced digital expertise has yet to experience significant growth (see Figure below).

The low shares can be partially attributed to the job titles professionals on LinkedIn have with many agri-food professionals included in the industrial ecosystems being active in roles such as food servers (4%), owners (4%), or cooks (2%) and it is hence not surprising that these do not list advanced digital skills (as identified above) on their profile.

Figure 48: Share of professionals in agri-food with advanced digital skills



Source: Technopolis Group based on LinkedIn

3.2.3. Demand for digital services by consumers

This section focuses on the demand of consumers for food safety and transparency. Two concrete applications that are being discussed in what follows are the demand for traceability of food products and smart or intelligent packaging and labelling.

Demand for the traceability of food products

The 2023 EIT Food Trust Report[200] indicates that in day-to-day purchases, consumers typically do not worry too much about **food safety** and that consumers are generally rather confident in the quality of food. Nevertheless, still 27% of the consumers have expressed a lack of trust in food manufacturers to bring safe foods to the market in 2023, a share that is rather stable over the past years[201]. Especially large multinationals are perceived as willing compromise sustainability and health for the sake of profitability.

At the same time, it is widely acknowledged that consumers show a **growing awareness** regarding the provenance and safety and quality of the food they consume, demanding comprehensive details on the source, production methods, and ingredient integrity. As a result, the market for **food traceability** is growing, mainly driven by consumer desire for **transparency**. Food traceability might be challenging especially for smaller companies given the high implementation costs related to investments to implement traceability systems (blockchain, IoT devices, data management software…), employee training, infrastructure, maintenance, and so on. From 2022 to 2023, the global food traceability market size has grown from EUR 14.6 bn to EUR 15.1 bn according to Global Market Insights[202], and is projected to grow by an 8% CAGR to EUR 31.9 bn in 2032. The market

[200] EIT Food (2024) Trust Report 2023.
[201] EIT Food (2024) Trust Report 2023.
[202] Global Market Insights (2024) Food Traceability Market - By Component (Hardware, Software, Services), By Deployment Mode (Cloud based, On-premises, Hybrid), By Technology, By Software, By Application & Forecast, 2024 –

share for food traceability in fish, meat, and seafood is currently the largest[203], and is also projected to be the fastest growing segment with a CAGR of over 10% between 2024 and 2032.

Demand for smart or intelligent packaging and labelling

Related to the consumers' demand for **safety and transparency**, **smart packaging and labelling** has become increasingly popular in recent years. Smart or intelligent packaging can monitor the quality status of a product permanently by providing information about events inside or outside the packaging environment and sharing the information with supply-chain actors, including retailers and consumers. As a result, smart packaging and labelling are also important in addressing the large food waste problem.

Given the costs and the fact that awareness and trust in the efficacy of such systems still needs to be built, smart packaging systems are not yet widespread in the market[204]. Nevertheless, recently, the global smart packaging market size was valued at EUR 21.25 bn in 2023, of which the food and beverage segment dominates the market (over amongst other electronics, e-commerce and pharmaceuticals)[205]. The entire global market is expected to grow, exhibiting a CAGR of 6.24% until 2032.

3.3. Impact of digital technologies on industrial competitiveness

What is the progress of industrial efforts towards digitalisation?

- Digital technologies support in **increasing the competitiveness** of the agri-food industrial ecosystem by finding **efficiency gains in production**, while at the same time increasing **resilience** and **limiting the impact of the industry** on the environment, while also enabling safety, security, traceability and the production of higher quality food products.

- The EU is an agricultural production leader, especially in segment of precision farming technologies. Further opportunities lie in **connecting technology developers with agri-food industrial ecosystem players** to adapt existing technologies to the specific needs.

- The EMI survey of agri-food companies reveals that the **adoption of advanced digital technologies has led to a notable 10% increase in productivity,** as measured by output per hour worked for the agri-food industrial ecosystem. Among the technologies driving this productivity boost, robotics was identified by respondents as having the greatest impact.

- Countries as Belgium, Netherlands and Poland that promote knowledge valorisation of digital and green technologies through strong co-location patterns also showcase a strong performance in the agri-food industrial ecosystem in terms of production, trade and patents.

2032. Retrieved from: https://www.gminsights.com/industry-analysis/food-traceability-market#:~:text=Food%20Traceability%20Market%20was%20valued,factors%20propelling%20the%20market%20growth

[203] compared to segments 'fruits & vegetables', 'fruit pulp & concentrates', 'dairy products', 'processed foods', and 'bakery & confectionary'.

[204] UNEP DTU Partnership and United Nations Environment Programme (2021) Reducing Consumer Food Waste Using Green and Digital Technologies. Copenhagen and Nairobi. Retrieved from: https://unepccc.org/wp-content/uploads/2021/11/reducing-consumer-food-waste-using-green-and-digital-technologies.pdf

[205] Fortune Business Insights (2024) Smart Packaging Market Size, Share & Industry Analysis Retrieved from: https://www.fortunebusinessinsights.com/smart-packaging-market-109166

This section analyses the extent to which companies perceive digital technologies as enhancing their competitiveness, both for their business and the industry. It also explores the reasons why investing in digital technologies is worthwhile and identifies which ones are particularly advantageous for the agri-food industrial ecosystem.

The European Commission's Political guidelines for 2024-2029 emphasize the significant potential the digitalisation of agriculture in Europe holds to enhance efficiency, effectiveness, sustainability, and competitiveness across the ecosystem[206]. The agri-food industrial ecosystem is comprised of both the agricultural & farming and food processing activities. As such the underlying digital technologies may differ depending on whether agriculture or food processing are in the primary scope of activities. In agriculture and farming, smart and precision farming underpin the drive towards the uptake of digital technologies, including the application of Internet of Things in the form of environmental and animal sensors, advanced manufacturing technologies such as drones, as well as photonics to monitor growth, whereas food processing industry strives to transition towards smart food processing by adopting different sensors targeted to needs related to temperature and hygiene, robotics for food assembly, and AI for process optimisation. Digital technologies support in increasing the competitiveness of the agri-food industrial ecosystem by finding efficiency gains in production, while at the same time increasing resilience and limiting the impact of the industry on the environment, while also enabling safety, security, traceability and the production of higher quality food products[207]. The use of digital technologies in agriculture can lead to several benefits like production optimisation, supporting farmers in making informed decisions; enhanced animal welfare by e.g. tracking health conditions; increased working conditions and transparency[208].

The EU is an agricultural production leader, especially in segment of precision farming technologies. Further opportunities lie in connecting technology developers with agri-food industrial ecosystem players to adapt existing technologies to the specific needs. Agriculture was one of the priority areas for the robotics programme within H2020, leading to several projects funded in the area of IoT and digital platforms such as IoF2020 and SmartAgriHubs[209]. Other projects have supported the use of digital solutions to make the food system more sustainable including the S3 FOOD project[210] spearheaded by the Smart Sensors for Agri-Food Partnership[211] under the S3 Thematic Platforms of the Smart Specialisation Community of Practice[212] which funded projects related to the application of smart sensors to monitoring production, support traceability, among others in the food industry.

The EMI survey of agri-food companies, conducted as part of this project, reveals that the adoption of advanced digital technologies has led to a notable 10% increase in productivity, as measured by output per hour worked. This suggests that businesses within the agri-food industrial ecosystem have successfully leveraged digital tools to enhance operational efficiency, notably in the smart food processing or precision agriculture domain. Among the technologies driving this productivity boost, robotics was identified by respondents as having the greatest impact. This can be attributed to opportunities both in agriculture, supporting farming round-the-clock and for repetitive tasks, as well as in food processing to support in food manufacturing through, e.g. the use of co-bots.

---

[206] https://digital-strategy.ec.europa.eu/en/policies/digitalisation-agriculture
[207] European Commission (2020) Advanced Technologies for Industry – Sectoral Watch. Technological Trends in the agri-food industry. Retrieved from: https://monitor-industrial-ecosystems.ec.europa.eu/sites/default/files/2020-09/ATI%20Technological%20trends%20in%20the%20agri-food%20industry.pdf
[208] https://digital-strategy.ec.europa.eu/en/policies/digitalisation-agriculture
[209] https://digital-strategy.ec.europa.eu/en/policies/digitalisation-agriculture-horizon-2020
[210] https://s3food.eu/projects/
[211] https://ec.europa.eu/regional_policy/policy/communities-and-networks/s3-community-of-practice/partnership_agrifood_smart_sensors_for_agrifood_en
[212] https://ec.europa.eu/regional_policy/policy/communities-and-networks/s3-community-of-practice_en

Table 1 The impact on productivity of advanced digital technologies as expressed by the share of respondents from agri-food (EU27)

	Cloud	IoT	Artificial Intelligence	Robotics	Big Data	Blockchain	AVR
Less than 1% of annual turnover	45.00%	48.65%	83.00%	20.00%	59.00%	50.00%	28.00%
1-5% of annual turnover	44.00%	21.62%	3.00%	18.75%	18.00%	16.00%	28.00%
6-10% of annual turnover	6.78%	5.41%		6.25%		4.00%	
11-30% of annual turnover	3.80%	6.67%			4.55%		14.00%
More than 30% of annual turnover		5.41%	3.23%	12.50%			

Source: EMI survey 2024

Note: the surveyed companies were asked has the adoption of specific technology increased your productivity? Productivity is proxied by the output per hour worked.

In addition, the use of robotics in agriculture and food production has supported tasks such as harvesting, sorting, and packaging, allowing for greater precision, speed, and cost efficiency. Robotics also reduces labour costs and minimises human error, which directly contributes to increased output. Artificial intelligence (AI) was ranked as the second most impactful technology. AI applications in the agri-food industrial ecosystem include predictive analytics, precision farming, and automated decision-making processes. AI helps companies optimize resource use, improve crop yields, and streamline supply chain management, all of which enhance overall productivity.

Appendix A: References

AgFunder (2024). Global AgriFoodTech Investment Report 2024. Retrieved from: https://agfunder.com/research/agfunder-global-agrifoodtech-investment-report-2024/

EIT Food (2022). Targeted nutrition: innovation to reduce dietary inequalities. Retrieved from: https://www.eitfood.eu/blog/targeted-nutrition-innovation-to-reduce-dietary-inequalities

EIT Food (2024). Trust Report 2023.

EOS Data Analytics (2024) Variable Rate Technology: What is this and how it works. Retrieved from: https://eos.com/blog/variable-rate-technology/

European Commission (n.d.) Biotechnology. Retrieved from: https://single-market-economy.ec.europa.eu/sectors/biotechnology_en

European Commission (2021). Renewable Energy and Agri-food Systems: Advancing Energy and Food Security towards Sustainable Development Goals. Retrieved from: https://knowledge4policy.ec.europa.eu/publication/renewable-energy-agri-food-systems-advancing-energy-food-security-towards-sustainable_en

European Commission (2024). Press release. Commission takes action to boost biotechnology and biomanufacturing in the EU. https://ec.europa.eu/commission/presscorner/detail/en/ip_24_1570

European Commission (2024) Transition pathway for the agri-food industrial ecosystem. Retrieved from: https://single-market-economy.ec.europa.eu/document/download/a2d02a42-b7d4-4dfd-affb-0d9510dd405c_en?filename=Transition%20Pathway%20for%20the%20agri-food%20industrial%20ecosystem%20-%20final_en.pdf

European Council (2024). Sustainable packaging: Council signs off on new rules for less waste and more re-user in the EU. Retrieved from: https://www.consilium.europa.eu/en/press/press-releases/2024/12/16/sustainable-packaging-council-signs-off-on-new-rules-for-less-waste-and-more-re-use-in-the-eu/

Eurostat (2024) Key figures on the European food chain – 2024 edition. Retrieved from: https://ec.europa.eu/eurostat/web/products-key-figures/w/ks-01-24-000

Fanzo, J., McLaren, R., Bellows, A., & Carducci, B. (2023). Challenges and opportunities for increasing the effectiveness of food reformulation and fortification to improve dietary and nutrition outcomes. Food Policy, 119, 102515.

FAO (n.d.). What is agricultural biotechnology? Retrieved from: https://www.fao.org/4/y5160e/y5160e07.htm

FAO (n.d.) Evaluation at FAO - Evaluating agri-food systems. Retrieved from: https://www.fao.org/evaluation/highlights/agri-food-systems/en

Food 4 Future – Expo FoodTech (2024) Biotechnology and Food: A glimpse into the future of the food industry. Retrieved from: https://www.expofoodtech.com/biotechnology-food-glimpse-future-food-industry/

Food packaging Forum (2024) European industry associations report latest recycling rates. Retrieved from: https://foodpackagingforum.org/news/european-industry-associations-report-latest-recycling-rates

Foodics (2025) Retrieved from: https://www.foodics.com/robotics-in-the-food-industry/

Global Market Insights (2024) Food Traceability Market - By Component (Hardware, Software, Services), By Deployment Mode (Cloud based, On-premises, Hybrid), By Technology, By Software, By Application & Forecast, 2024 – 2032. Retrieved from: https://www.gminsights.com/industry-analysis/food-traceability-market#:~:text=Food%20Traceability%20Market%20was%20valued,factors%20propelling%20the%20market%20growth

Grassano, N., Napolitano, L., M`barek, R., Rodriguez Cerezo, E. and Lasarte Lopez, J., Exploring the global landscape of biotech Innovation: preliminary insights from patent analysis, Publications Office of the European Union, Luxembourg, 2024, doi:10.2760/567451, JRC137266.

Invesco (2021) Invesco Global Factor Investing Study. Retrieved from: https://www.invesco.com/content/dam/invesco/emea/en/pdf/Invesco-Global-Factor-Investing-Study-2021-EMEA.pdf

IRENA & FAO (2021). Renewable energy for agri-food systems – Towards the Sustainable Development Goals and the Paris agreement. Abu Dhabi and Rome. Retrieved from: https://doi.org/10.4060/cb7433en

Market Research Wire (2025). Europe Agriculture IoT Market. Retrieved from: https://marketresearchwire.com/europe-agriculture-iot-market/

Oliver Wyman and CDP (2023) Stepping up: Strengthening Europe's corporate climate transition. Retrieved from: https://www.oliverwyman.com/content/dam/oliver-wyman/v2/publications/2023/feb/cdp-europe-report.pdf

StartUs Insights (2024). Uncover the Top 10 Agriculture Trends, Technologies & Innovations in 2025. Retrieved from: https://www.startus-insights.com/innovators-guide/agriculture-trends-innovation/

UNEP DTU Partnership and United Nations Environment Programme (2021). Reducing Consumer Food Waste Using Green and Digital Technologies. Copenhagen and Nairobi. Retrieved from: https://unepccc.org/wp-content/uploads/2021/11/reducing-consumer-food-waste-using-green-and-digital-technologies.pdf

World Health Organisation (2022). WHO European Regional Obesity Report 2022. Retrieved from: https://iris.who.int/bitstream/handle/10665/353747/9789289057738-eng.pdf?sequence=1

Appendix B: Methodological notes

Crunchbase and Net Zero Insights

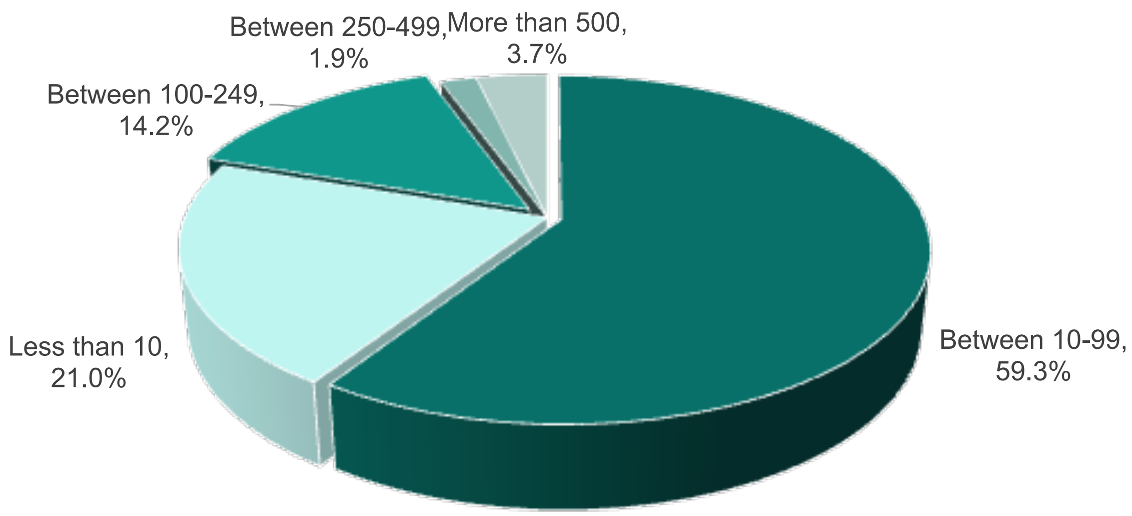
Tags used in the analysis:

- **Agriculture and Farming** Agriculture, AgTech, Animal Feed, Aquaculture, Farming, Horticulture, Hydroponics, Livestock,
- **Food and Beverage** Bakery, Brewing, Catering, Coffee, Confectionery, Craft Beer, Dietary Supplements, Distillery, Farmers Market, Food and Beverage, Food Delivery, Food Processing, Food Trucks, Fruit, Grocery, Nutrition, Organic Food, Seafood, Snack Food, Tea, Tobacco, Wine And Spirits, Winery, Restaurants

EMI Survey 2024 – Sample of agri-food companies

The EMI Survey 2024 included a total of 706 companies were included and the following sample distribution of companies from the agri-food industrial ecosystem (see Figure 49).

Figure 49: Survey sample distribution according to company size – agri-food



Source: EMI Enterprise survey 2024

Exiobase

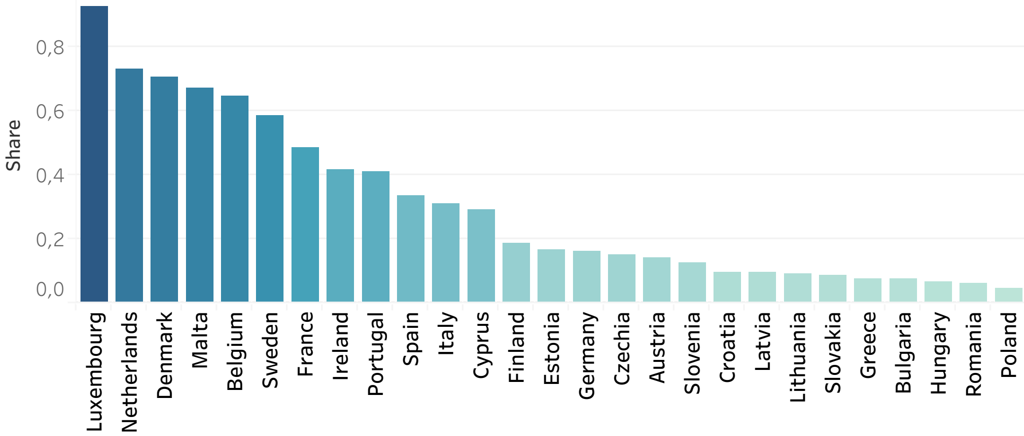
Exiobase is a time series of environmentally extended multi-regional input-output (EE MRIO) tables. Its coverage is by country and industry from 1995 to 2021 and has EU and extra rest of the world coverage. Source: Stadler, Konstantin, Wood, Richard, Bulavskaya, Tatyana, Södersten, Carl-Johan, Simas, Moana, Schmidt, Sarah, Usubiaga, Arkaitz, Acosta-Fernández, José, Kuenen, Jeroen, Bruckner, Martin, Giljum, Stefan, Lutter, Stephan, Merciai, Stefano, Schmidt, Jannick H, Theurl, Michaela C, Plutzar, Christoph, Kastner, Thomas, Eisenmenger, Nina, Erb, Karl-Heinz, … Tukker, Arnold. (2021). EXIOBASE 3 (3.8.2) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.5589597

LinkedIn Representativeness

To perform a representativeness analysis of LinkedIn, the available industry-specific dataset has been compared to Eurostat figures regarding the active population in the industrial ecosystem. The results show that countries such as Luxembourg and the

Netherlands, as well as Denmark, Malta and Belgium have a higher amount of persons active in the agri-food industry active on LinkedIn as compared to countries such as Greece, Bulgaria, Hungary, Romania and Poland.

Figure 50: Representativeness of agri-food industry professionals on LinkedIn compared to Eurostat statistics on persons employed in agri-food



Source: Technopolis Group calculations based on LinkedIn vs Eurostat - annual enterprise statistics for special aggregates of activities (NACE Rev. 2)

Green skills – keywords used: Cleantech, Sustainability, Sustainable Development, Sustainable Business, Energy Efficiency, Clean Energy Technologies, Renewable Energy, Wind Energy, Biomass, Biomass Conversion, Solar Energy, Solar Power, Urban Forestry, Forest Ecology, Sustainable Communities, Organic Farming, Organic Gardening, Urban Agriculture, Organic Food, Waste Management, Waste Reduction, Recycling, Water Treatment, Water Resource Management, Water Purification, Green Marketing, Green Printing, Environmental Biotechnology, Environmental Science, Environmental Engineering, Environmental Management Systems, Environmental Protection, Wastewater Treatment, Ecology, Circular Economy, Zero Waste, Waste to Energy, Plastics Recycling, E-Waste, Carbon Reduction Strategies, Carbon Footprinting, Carbon Neutral, Energy Retrofits, Biodiversity, Biodiversity Conservation, Nature Conservation, Advanced Materials, Nanomaterials, Biomaterials, Reuse, Separation Process, Sorting, Equipment Repair, Natural Resource Management, Sustainability Reporting, Green Development, Sustainable Cities, Energy Conservation, Energy Management, Environmental Awareness, Environmental Impact Assessment, Environmental Compliance, Leadership in Energy and Environmental Design (LEED), Environmental Policy, Green Technology, Sustainable Design, Sustainable Architecture, Environmental Consulting, Maintenance and Repair, Solar PV, Solar Cells, Wind Turbines, Wind Turbine Design, Carbon Capture, Low Carbon Technologies, Low Carbon, Renewable Fuels, Renewable Energy Systems, Renewable Resources, Integrated Water Resources Management, Natural Resources, Biodiesel, Bioplastics, Waste Treatment, Waste Water Treatment Plants, Electric Vehicles, Hybrid Electric Vehicles, Multi-modal Transportation, Energy Efficiency Consulting, Recycled Water, Adaptive Reuse, Ecodesign, Life Cycle Assessment, Energy Optimisation, Alternative Fuels, Green Building, Green Infrastructure, Green Purchasing, Biodegradable Products, ISO 14001, EMAS, Environmental Standards

Digital skills – keywords used: data analytics, online platforms, digital payment, online ticketing, Cybersecurity, Intrusion Detection, Malware Detection, Cloud Security, Cybercrime Investigation, Cyber Threat Intelligence (CTI), Cryptography, DLP, Malware Analysis, IDP; Vulnerability Assessment, Certified Information Security Manager (CISM), Computer Forensics, Cloud Infrastructure, Cloud Services, Google Cloud Platform (GCP), SAP Cloud Platform, SAP HANA, Everything as a Service (XaaS), Software as a Service (SaaS), Platform as a Service (PAAS), Infrastructure as a Service (IaaS), Private Clouds, Hybrid Cloud, Cloud Computing, Edge Computing, High Performance Computing (HPC), Serverless Computing, Robotics, Robot, Robotic Surgery, Human-robot Interaction, Drones, Connected Devices, Internet of Things (IoT), Robotic Process Automation (RPA), Wireless Sensor Networks, Embedded Systems, Cyber-Physical Systems, Smart Cities, Artificial Intelligence (AI), Biometrics, Cognitive Computing, Computer Vision, Deep Learning, Machine Learning, Natural Language Processing (NLP), Natural Language Understanding, Natural Language Generation, Reinforcement Learning, Speech Recognition, Supervised Learning, Unsupervised Learning, Big Data Analytics, Hadoop, Real-time Data, Yarn, Teradata Data Warehouse, Blockchain, Ethereum, Bitcoin, Cryptocurrency, Crypto, Distributed Ledger Technology (DLT), Hyperledger, Augmented Reality (AR), Virtual Reality (VR), Mixed Reality, Computer-Generated Imagery (CGI), Connectivity, M2M, 5G, SD-WAN, Home Automation, Flexible Manufacturing Systems (FMS), Smart Manufacturing, Smart Materials, Quantum Computing, Smart Devices, Intelligent Systems, Big Data, Computer-Aided Design (CAD), Computer Science, MATLAB, C (Programming Language), Python (Programming Language), Digital Strategy, Digital Printing, Digital Marketing, Online Journalism, Revit, Building Information Modeling (BIM), JavaCard, R (Programming Language), Digital Imaging, Digital Media, C++, Collaborative Robotics, Industrial Robotics, Medical Robotics, Mobile Robotics, AutoCAD, Automation, Autodesk 3ds Max, Lumion, Data Analysis, Data Mining, 5G Core, Integrated Security Systems, Cloud Applications, Cloud Computing IaaS, Cryptocurrency Mining, CryptoAPI, Automated Machine Learning (AutoML), Machine Learning Algorithms, Virtual Reality Development, Virtual Data Rooms, Intelligence Systems, Robot Programming, Predictive Analytics, Data Lakes, Blockchain Analysis, Digital Publishing, Enterprise Software, Software Development, SAS (Software), SAP Products, SAP ERP, Online Payment, Online Payment Solutions; Online Travel, Online Marketing, Online Business Management, Online Advertising, Online Gaming, Web Services, Mobile Applications, Mobile Marketing, Java Database Connectivity (JDBC), Data Warehousing, Statistical Data Analysis, Data Modeling, Databases; Electronic Data Capture (EDC), Data Centers, Oracle Database, SAP Solution Architecture Data Entry, Data Management, Data Mapping, Web Applications, GIS Applications, Oracle Applications, Visual Basic for Applications (VBA), Computer Hardware, Computer Maintenance, Computer Network Operations, Computer Networking, Computer Graphics, Online Communications, Social Media Marketing, Digital Direct Marketing, Digital Illustration, Digital Video, Digital Photography, Xero, GPS Applications, GPS Devices, GPS Tracking, GPS Navigation, Microsoft Power Apps, Social Networking Apps, Google Apps Script, Social Media, E-Commerce, Data Intelligence, Online Platforms, Mobile Payments

GETTING IN TOUCH WITH THE EU

In person

All over the European Union there are hundreds of Europe Direct information centres. You can find the address of the centre nearest you at: https://europa.eu/european-union/contact_en

On the phone or by email

Europe Direct is a service that answers your questions about the European Union. You can contact this service:

– by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),

– at the following standard number: +32 22999696, or

– by email via: https://europa.eu/european-union/contact_en

FINDING INFORMATION ABOUT THE EU

Online

Information about the European Union in all the official languages of the EU is available on the Europa website at: https://europa.eu/european-union/index_en

EU publications

You can download or order free and priced EU publications from: https://op.europa.eu/en/publications. Multiple copies of free publications may be obtained by contacting Europe Direct or your local information centre (see https://europa.eu/european-union/contact_en).

EU law and related documents

For access to legal information from the EU, including all EU law since 1952 in all the official language versions, go to EUR-Lex at: http://eur-lex.europa.eu

Open data from the EU

The EU Open Data Portal (http://data.europa.eu/euodp/en) provides access to datasets from the EU. Data can be downloaded and reused for free, for both commercial and non-commercial purposes.

EA-01-25-093-EN-N

Publications Office
of the European Union

ISBN: 978-92-9412-168-4