Patent Landscape Report

Agrifood

WIPO

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Key findings

Patenting in the vast Agrifood super-domain is largely protected domestically

The Agrifood sector is vast and comprises over 3.5 million published patent families (inventions) over the past 20 years, which are split into two main categories: AgriTech, representing 60% of the total patent count (2.1m), and FoodTech, making up the remaining 40% (1.5m). Most Agrifood patents come from Asia, with China, Japan, the Republic of Korea and India as major contributors, followed by North America and Europe. Only 12% of patent families (450,000) are filed outside of their IP office of first filing. Notably, patent applications from Asia, specifically those from China, are more likely to seek patent protection only within their home countries.

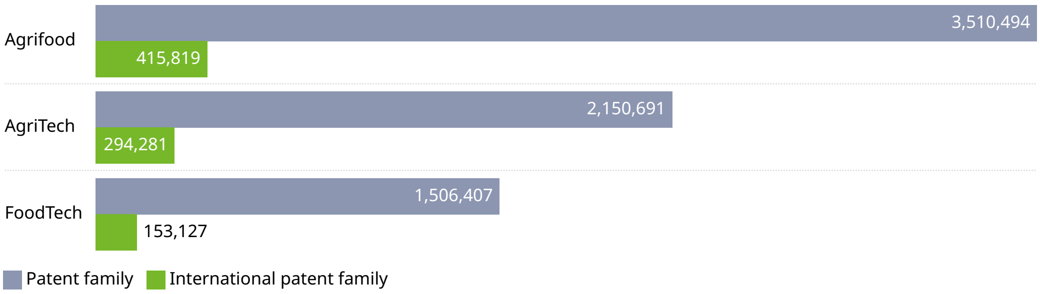
The United States has always been a dominant player, but recent increases in R&D investment by China and Japan appear to be changing the global patent landscape in the Agrifood sector

Of the 450,000 international Agrifood patent families, 66% are in AgriTech and 34% in FoodTech. In recent years, both industries have experienced moderate annual growth rates, 6.9% in AgriTech and 3.3% in FoodTech respectively.

The United States has historically been a key player in Agrifood, but recent growth in R&D investments in China and Japan, with impressive annual growth rates, signal a possible shift in the global landscape of the Agrifood super-domain.

More than 3.5 million patent families have been published in the Agrifood sector over the past 20 years, with around 12% being international patent families.

Number of patent families and international patent families for the Agrifood super-domain, comprising the AgriTech and FoodTech domains



Note: For complete notes, see Chapter 2, Figure 2.1 and 2.2.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

AgriTech patent growth is attributed to the increasing interest in agricultural automation and IoT technologies

AgriTech sub-domains with the most patents over the last two decades are *Pest/disease management, Crop adaptation and genetics, Livestock management*, and IoT-related areas such as *Connectivity/sensors/smart farming, Precision agriculture and Mapping/imagery*. Additionally, *Planting/harvesting/storage, Robotics and drones*, and *Soil and fertilizer management* have also seen significant developments since 2004.

The top AgriTech inventor locations are the United States, followed by Asian countries such as China, Japan and the Republic of Korea.

The top filing authorities show a focus on *Pest/disease management and Crop adaptation and genetics*, with Germany standing out in *Connectivity/sensors/smart farming innovations*.

The top AgriTech patent applicants are industrial manufacturers of agricultural machines from the US, Japan and Europe, and agrochemical companies from Germany, China and Japan. Technology companies from Asia are prominent in IoT-related sub-domains.

Supply chain and Food chemistry lead FoodTech research, with the United States as the primary R&D hub

In FoodTech, the top patenting sub-domain over the past 20 years relates to the *Supply chain*, followed by *Food chemistry, Food technology, Consumer technology and Food services*. The overall growth of FoodTech sub-domains has been relatively stagnant, with the exception of *Food chemistry* and *Food services*, which have benefited from increased investment in alternative and sustainable nutrition sources.

The United States is the primary location for FoodTech patenting, with Asia and Europe also playing key roles in specific areas. When analyzing the top filing authorities, *Supply chain, Food chemistry* and *Food technology* are prevalent, with Asia leading in *Food chemistry* and Israel focusing on developing new alternative nutrient sources for human food. Different companies lead in each sub-domain, with Nestlé, unsurprisingly, emerging as a significant player in FoodTech.

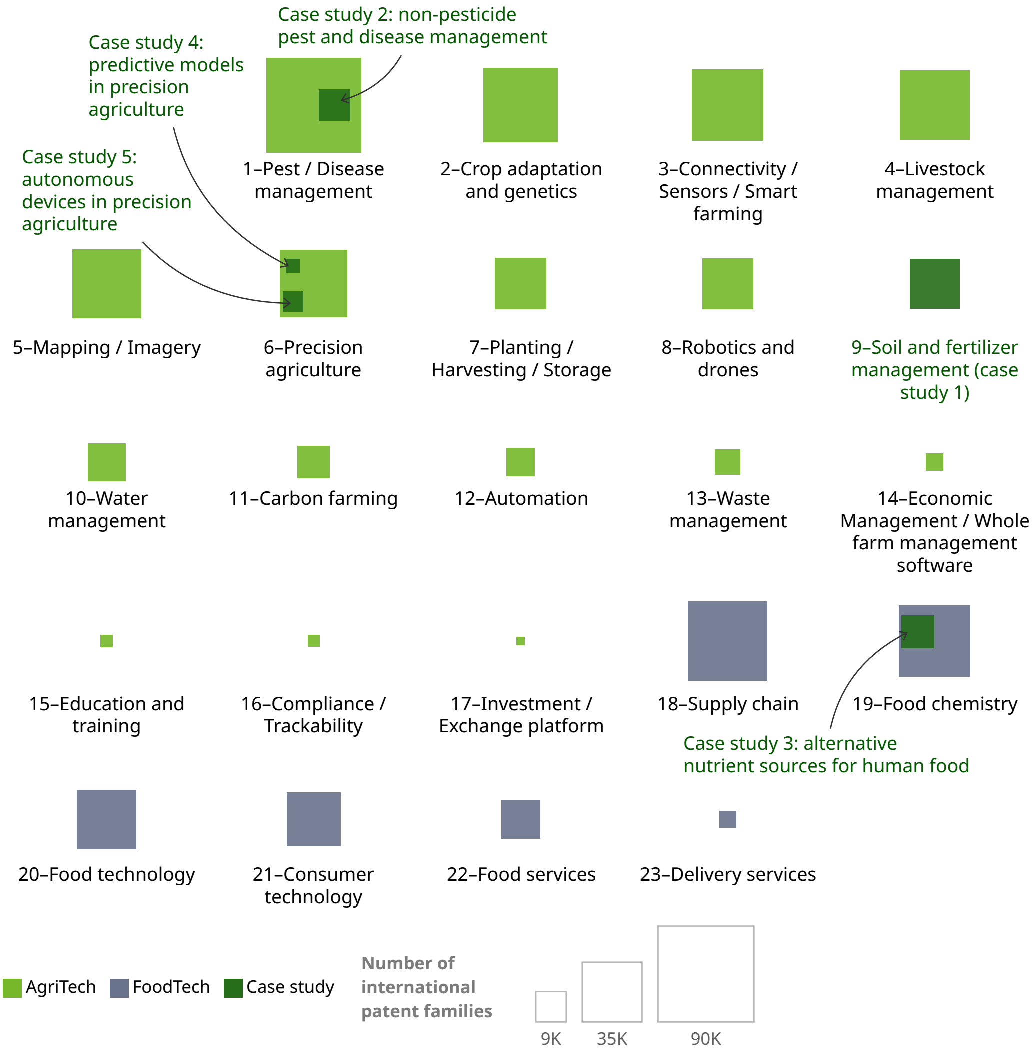
Precision agriculture, soil and fertilizer management, non-pesticide pest and disease management, and alternative nutrients are key research hotspots in Agrifood industries

Research hotspots can be categorized into four groups:

1. **Precision agriculture** – this is the most prominent segment, and includes advancements in robotic/autonomous agriculture vehicles and automation through artificial intelligence (AI) and software
2. **Soil and fertilizer management** – this has emerged as the second leading sub-domain, encompassing general soil management systems and innovative fertilizer formulations
3. **Non-pesticide pest and disease management**, especially the use of microorganisms in fertilizer formulation and as pesticide alternatives
4. The exploration of **Alternative sources of nutrients for sustainable human food** – this also stands out as a significant area of development within the Agrifood sector.

Increasing interest in agricultural automation and IoT technologies has driven AgriTech patent growth, whereas FoodTech research is led by Supply chain and Food chemistry advancements.

Number of international patent families in the AgriTech and FoodTech sub-domains



Note: For complete notes, see Chapter 2, Figure 2.8 and 2.13.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

North America dominates patenting in the Soil and fertilizer management AgriTech sub-domain

The data collected from 23,736 international patent families in the *Soil and fertilizer management* sub-domain from 2017 to 2021 shows a moderate annual growth rate of +5.6%, reflecting increasing interest. North America leads in patent filings, followed by Europe and Asia. The United States is the primary R&D location for *Soil and fertilizer management*, but significant growth is seen in Asia, particularly in India and China.

Autonomous guidance and fertilizer formulations are leading technology trends, with microorganism-enriched fertilizers and autonomous guidance booming. Top players in the segment are manufacturers of agricultural machineries and German chemical companies. Emerging technologies in the *Soil and fertilizer management* domain point towards autonomous guidance of agricultural machines and innovative soil analysis methods.

Flat growth in patent activity and high specificity of pest control methods reflect the challenges in Non-pesticide pest and disease management

Over the past decade, sustained patent filing activity has been observed in the field of non-pesticide pest and disease management, showcasing various innovative approaches to control crop pests without relying on chemical pesticides. These approaches include the use of living organisms, compositions, devices and genetic modification. Regional policies from countries such as China, Japan, the Republic of Korea, France, Spain and the United Kingdom support sustainable agriculture practices and reduction in pesticide usage. The top patent applicants in this domain are industrial actors such as BASF and Bayer, with a focus on diverse biocontrol technologies.

A flat growth is characteristic to the whole sub-domain, with a slow trend identified in microorganism use. The absence of a disruptive technology that would stop the use of conventional pesticides, even under regulatory pressure from the state, probably reflects the nature of this pest protection approach characterized by very high specificity: one biocontrol agent can be used to prevent or treat only a very restrained group of closely related infections or pests. A semantic analysis of key concepts in pest control patents highlighted legume cultures and moths as the most targeted culture types and pests, respectively, with specific methods and compositions designed to target particular species of pests.

Significant investments and strategic partnerships propel growth in patents for alternative nutrient sources

In recent years, there has been a notable surge in innovative solutions within the food industry aimed at providing alternative proteins to traditional animal products, driven by a growing interest in sustainable food options. This trend has attracted significant investments, with venture capital flowing into startups specializing in alternative meat products, as well as egg-free and dairy-free products.

Patent filings in the field have shown a moderate growth rate, with North America leading but closely followed by Asia and Europe. Major players such as Nestlé, Bayer and Cargill are broadening their portfolios to include insect-, algae- and plant-based proteins. Startups are forming partnerships with fast-food chains and retail stores to promote their alternative meat products, while traditional meat-processing companies are also investing in alternative protein innovations.

The industry is embracing a range of technology groups, including plant-based alternatives, insect proteins, precision fermentation, biomass fermentation, cell-based meat and molecular farming, with a focus on creating sustainable and nutritious food products. Israel, for example, aims to reduce animal protein consumption and invest in innovative food companies to promote sustainable food systems.

Predictive models in precision agriculture show huge growth, led by the United States and Asia

The analysis of data from 1,500 international patent families in the *Predictive models in precision agriculture* field reveals a significant recent annual growth rate of +27.1%, indicating a surge in interest in the subject matter. North America, particularly the United States, leads in patent filings, followed closely by Asia, with China, Japan and the Republic of Korea showing significant growth. Various countries worldwide are investing in evidence-based science programs for effective conservation and climate-smart practices in agriculture.

The top players in the predictive models sub-domain, dominated by corporate actors, include companies from the United States, Germany and Japan, focusing on innovative technologies for crop prediction and management.

The application of predictive models within AgriTech is expanding globally, with a focus on soil management, plant culture and animal husbandry, while also showing potential for FoodTech applications. In addition, emerging technologies such as honey bee colony monitoring and flood discharge prediction are gaining momentum in the field.

Autonomous devices in precision agriculture exhibit high patent growth, driven by China, the United States and Germany

The *Autonomous devices in precision agriculture* field is experiencing a notable increase in interest, with a recent annual growth rate of +10.4%. China, the United States and Germany are the main providers of solutions for autonomous guidance, with Deere leading the way in the United States. Various strategies are being implemented globally to promote the digitalization of agriculture and increase sustainable productivity. The use of *Autonomous devices in precision agriculture* is growing rapidly, with a focus on soil management, crop harvesting and food processing to improve efficiency and productivity within the industry.

1 Introduction

This chapter outlines the research background, objectives, scope, and technical taxonomy of the Agrifood sector studied in this report. The Agrifood sector includes two domains: AgriTech and FoodTech, which are further categorized into 23 sub-domains.

Maintenance of food security is a major concern worldwide and will be for decades to come.[1] In the next 25 years, the global population is projected to increase by 20%, reaching an estimated 9.7 billion by 2050.[2] This growth will present numerous challenges, particularly due to expanding urbanization that will impact the availability of natural resources and limited agricultural land.[3] Furthermore, the effects of climate change on crop yield and livestock production will continue to pose significant challenges. Additionally, there is expected to be a growing demand for animal-protein food, such as meat, fish, eggs and dairy products, driven by rising incomes worldwide. It is estimated that by 2050, the demand for food will increase by 56% compared to the levels in 2013.[4]

There is a growing necessity to implement efficient strategies to uphold worldwide food security. We have witnessed the contrasting effects on hunger and food insecurity over the last few years, particularly when the war in Ukraine disrupted global commodity and energy markets as the world was still recovering from the COVID-19 pandemic.[5]

The investment in Agrifood technology has seen a substantial rise, growing from US$3 billion in 2012 to nearly US$30 billion in 2022.[6] An increasing number of entrepreneurs and technology experts are entering the field as they explore potential technological solutions to tackle the challenges facing food security. Their goal is to enhance food production by making it more efficient, scalable, sustainable and resilient to various environmental conditions.

Innovation in the Agrifood sector plays a pivotal role in advancing progress towards the achievement of the UN Sustainable Development Goals (SDGs), as discussed in WIPO's recent analytical publication *Mapping Innovations: Patents and the SDGs*.[7] Fifteen of the seventeen SDGs can be improved by growth in the Agrifood sector,[8] including the eradication of poverty, the promotion of sustainable agriculture, and the attainment of food security. Achievement of such initiatives will require coordinated actions on several fronts: synergic cross-sectoral investments and collaboration, as well as coherent policies at regional and international levels.

1 Global Report on Food Crises - GRFC 2024 (www.fsinplatform.org/report/global-report-food-crises-2024/
2 United Nations (www.un.org/en/global-issues/population#:~:text=Our%20growing%20population&text=The%20world's%20population%20is%20expected,billion%20in%20the%20mid%2D2080s).
3 Chapter 3 of the World Intellectual Property Report (WIPR) 2024 discusses the importance of local capabilities in the agricultural sector (https://www.wipo.int/web/world-ip-report/2024-making-innovation-policy-work-for-development).
4 World Resources Institute (www.wri.org/insights/how-sustainably-feed-10-billion-people-2050-21-charts).
5 Food and Agriculture Organization of the United Nations (www.fao.org/publications/home/fao-flagship-publications/the-state-of-food-security-and-nutrition-in-the-world).
6 AgFunder (https://agfunder.com/research/agfunder-global-agrifoodtech-investment-report-2023/).
7 https://www.wipo.int/web/patent-analytics/mapping-innovations-patents-sustainable-development-goals
8 Agrifood touches on 15 of the 17 UN SDGs, namely on standards of living, inequality and economic growth (SDGs 1, 5, 8, 9, 10 and 16), good health (SDGs 2, 3, 6), environmental stability (SDGs 6, 7, 11, 12, 13, 14, and 15). See the 17 Goals of the UN SDGs at: https://sdgs.un.org/goals.

A contrasted worldwide situation for food security

The current worldwide sentiment about food security is mainly steered by the inequality in accessing food, food waste and the impact of global trade policies on food prices and availability.

Since 2019, FAO's Data Lab (Food and Agriculture Organization of the United Nations) has been monitoring indicators of food security,[9] including sentiment and popularity of topics associated with food security.[10]

According to FAO, over the past two decades, the global prevalence of undernourishment has decreased by 3.7%, from 2000 to 2022. However, recent data indicates a concerning trend with a 1.5% increase in barriers to food access over the past decade. This resurgence is particularly evident when examining global food security trends. In the last ten years, there has been a noticeable increase in the prevalence of moderate or severe food insecurity in Africa (16.4%), Latin America (13%), and Asia (6.5%). Of particular concern is the significant rise in food insecurity among female adults, with a 36% increase compared to males.

Additionally, FAO's analysis of global national press coverage in 2024 reveals that the overall sentiment regarding food security is somewhat positive, with a sentiment score of 58%.[11] This sentiment has remained relatively stable on a global scale over the past six months. However, there are notable discrepancies in certain regions, including recent reports of deteriorated food security situations in various Asian countries such as Myanmar, Philippines, Japan, Nepal, Islamic Republic of Iran, Israel and Türkiye.

Concerns have also been raised in European countries such as Poland, Finland, Estonia, Bosnia and Herzegovina, North Macedonia and Hungary, as well as in Southern African nations such as Botswana and Zambia, and locations in Latin America and the Caribbean such as Argentina, Uruguay, Cuba and French Guiana.[12]

Countries around the world are taking proactive steps to tackle food security issues by enacting policies and launching programs aimed at boosting agricultural productivity, enhancing access to nutritious food, and advocating for sustainable farming practices. International organizations, governments, and non-profit entities are collaborating on initiatives such as the SDGs and the World Food Program to address these challenges.[13] This concerted effort is crucial, as statistics show that approximately 282 million people worldwide suffer from high levels of acute food insecurity.[14]

Diversity of regional policies as a prerequisite of an integrated food system

Understanding the complex interactions between agriculture, food systems and the environment is crucial in ultimately ensuring sustainable practices which support relevant food system transformations that respond to local challenges. The World Intellectual Property Report 2024 underscores the importance of adapting agricultural innovation to local agroecological conditions, highlighting how regional specificities play a pivotal role in shaping effective policies.[15] Reliability of food systems knowledge, tailored from these local specificities, is the cornerstone for effective policymaking, thus avoiding the guesswork in translating commitments into practice.

9 Food and Agriculture Organization of the United Nations, FAOSTAT (www.fao.org/faostat/en/#data).
10 Food and Agriculture Organization of the United Nations, FAOSTAT, Topics Explorer – News (https://foodandagricultureorganization.shinyapps.io/topics-explorer-news/).
11 Food and Agriculture Organization of the United Nations, FAOSTAT, Topics Explorer – News (https://foodandagricultureorganization.shinyapps.io/topics-explorer-news/).
12 Food and Agriculture Organization of the United Nations, FAOSTAT, Topics Explorer – News (https://foodandagricultureorganization.shinyapps.io/topics-explorer-news/).
13 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/).
14 Global Report on Food Crises - GRFC 2024 (www.fsinplatform.org/report/global-report-food-crises-2024/).
15 World Intellectual Property Report 2024 (https://www.wipo.int/web-publications/world-intellectual-property-report-2024/en/index.html).

Intense efforts from FAO and the United Nations Food Systems Coordination Hub[16] have led to a regional quantification of policy and regulation themes related to food security worldwide. A list of 44 themes that emerged as recurrent areas of interest has been monitored since 2021 (Figure 1.1). Although this metric does not take into account the degree of consideration of each policy for a location, the global quantification of regional policies remains representative of a national interest for a given thematic area. Overall themes associated with food security have been segmented into four main action areas:

- Nourish all people
- Boost nature-based solutions of production
- Advance equitable livelihoods, decent work and empowered communities
- Build resilience to vulnerabilities, shocks and stresses.

16 See www.unfoodsystemshub.org/en.

Food security policies differ across regions due to factors like climate, economic development and political priorities.

Figure 1.1 Mapping of the relative number of regional policies associated with food security

1: Nourish all people	Africa	Asia	Europe	Latin America and Caribbean	North America	Oceania
Achieving zero hunger	67	94	16	117	13	2
Healthy diets from sustainable food systems for children and all	36	49	32	78	3	4
Food quality and safety	32	94	12	38	1	2
Social protection for food systems transformation	27	23	1	40	1	0
Sustainable consumption	22	66	21	41	0	0
Family farming	17	11	17	46	0	0
School meals: nutrition and health and education for every child	16	20	6	37	3	1
Food loss and waste	12	55	27	31	1	1
Different forms of malnutrition	11	17	5	34	1	0
The true value of food	4	3	2	7	0	0

2: Boost nature-based solutions of production	Africa	Asia	Europe	Latin America and Caribbean	North America	Oceania
Sustainable productivity growth	46	51	32	101	16	3
Aquatic/Blue foods	37	72	8	47	1	14
Agroecology	29	12	19	51	0	3
Land	29	33	5	40	2	1
Water	24	51	13	37	0	0
Nature-positive innovation	20	52	14	29	0	5
Restoring grasslands and shrublands and savannahs	16	5	2	16	0	0
Sustainable livestock	10	27	29	13	6	1
Soil health	8	26	3	15	1	
Agrobiodiversity	5	20	3	16	1	0
Halting deforestation and conversion from agricultural commodities	4	4	7	14	2	1

3: Advance equitable livelihoods, decent work, and empowered communities	Africa	Asia	Europe	Latin America and Caribbean	North America	Oceania
Food systems for women and girls	49	30	5	75	6	4
Youth food systems	31	20	4	42	3	3
Decent work and living incomes and wages for all food systems workers	24	33	13	42	5	1
Vulnerable people food systems	21	22	3	38	1	3
Indigenous people's food systems	6	11	1	22	17	0
Urban food systems	2	0	0	4	0	0

4: Build resilience to vulnerabilities, shocks, and stresses	Africa	Asia	Europe	Latin America and Caribbean	North America	Oceania
Climate and disasters resilient development pathways (CRDP)	39	58	39	104	9	7
Resilient food supply chains	38	56	25	60	1	0
Resilience to shocks and violent conflicts and food crisis	20	11	1	26	1	0
Resilience to health crises	3	17	11	26	3	1

Source: United Nations Food Systems Coordination Hub.

Globally 'nourish all people' is the most embodied group of policies for each continent. Solving hunger as well as developing sustainable and healthy food are the two main themes worldwide related to this group. The second predominant initiatives relate to 'boost nature-based solutions,' with major representation in Oceania. It includes sustainable productivity growth worldwide, with marked regional specificities including aquatic foods in Oceania, Asia and Africa, and sustainable livestock and agro-ecology in North America and Europe.

Remaining action areas (i.e. equitability, climate change resilience) are contrastingly represented depending on continents. It represents 50% of the total initiatives in North America, mostly due to 'indigenous peoples food systems' and 'climate and disasters resilient development' segments.

Latin America and the Caribbean, Africa and Oceania share the same profile with close to 40% of the overall policies dedicated to equitability and resilience, mostly for women-dedicated food systems and climate-resilient developments. Europe and Asia only dedicate 30% of their policies to climate change themes and the improvement of work conditions.

The multicentric innovative sector of Agrifood

By exploring innovative technologies, policies and practices of Agrifood, the goal is to promote useful, efficient, sustainable and resilient initiatives supporting food security for future generations. Agrifood is a multifaceted and dynamic area of innovation that requires interdisciplinary collaboration and a holistic approach to address the opportunities, strengthening the production, processing and distribution of food and agricultural products.

This WIPO Patent Landscape Report provides observations on patenting activity in the field of Agrifood technologies.

Agrifood is depicted as the conjunction of AgriTech and FoodTech domains, both harnessing the power of data analytics, biotechnology and automation.

AgriTech involves the application of cutting-edge technologies such as drones, sensors and artificial intelligence (AI) to enhance crop yields, optimize water usage and improve soil health.

FoodTech focuses on developing new and innovative solutions for food production, processing and delivery, with a particular emphasis on sustainability, food safety and nutrition.

The AgriTech domain is the convergence of the following seventeen sub-domains:

- *Automation* in agriculture is IT-related methods helping farmers to make data-driven decisions by providing real-time information on crop conditions, weather patterns and other factors that affect crop growth and yield.
- *Carbon farming* is a system of agricultural management that helps the land accumulate and store more greenhouse gases instead of releasing those gases into the atmosphere.
- *Compliance/trackability* refers to the ability to trace and track products or processes within the agricultural supply chain to ensure they meet regulatory requirements and industry standards.
- *Connectivity/sensors/smart farming* is built upon the foundation of interconnected devices and IoT sensors that synergize to usher in a transformational change in how farms are managed and operated.
- *Crop adaptation and genetics* support the heightened production of nutritional food and the reduction of crop losses imposed by extreme events like droughts, high temperatures, floods, diseases and pests.
- *Planting/harvesting/storage* relates to agricultural processes and machineries dedicated to crop management.
- *Education and training* is the instruction, teaching and training surrounding agriculture as well as the management of land and natural resources.
- *Economic management/whole farm management* software is used to optimize and manage farm operations and production activities, including forecasting and measuring profits,

developing crop plans, measurement of field activities, and risk management: erratic weather conditions, diseases, pests and unpredictable market demands.
- *Investment/exchange platform* is a type of financial service that provides opportunities for investors to support sustainable farming practices, agribusinesses or agricultural technologies. Investors can typically browse through different projects, select ones that align with their investment goals and contribute funds towards the development and growth of the chosen projects.
- *Livestock management* involves the management of farm animals and supervision of farm workers.
- *Mapping/imagery* services refers to the use of aerial or satellite imagery to gather data and create detailed maps of agricultural fields. These maps can provide valuable information about the health, size and composition of crops, as well as identify areas of stress or disease. By analyzing this data, farmers can make more informed decisions about irrigation, fertilization and pest control, ultimately leading to improved crop yields and more sustainable farming practices.
- *Pest/disease management* through chemical pesticides, and biocontrol methods: environmentally friendly approaches involving the introduction of natural enemies, such as predators, parasites or pathogens, to control the population of harmful organisms.
- *Precision agriculture* encompasses auto steer, wireless telematics, variable rate technology, indoor agriculture, remote sensing and data collection as well as predictive yield analytics and monitoring.
- *Robotics and drones* automate slow, repetitive and dull tasks for farmers, allowing them to focus more on improving overall production yields.
- *Soil and fertilizer management* refers to solutions improving the health and fertility of soil, including crop rotation, cover cropping, organic fertilizers, with minimized use of chemical fertilizers and pesticides.
- *Waste management* refers to solutions that minimize negative environmental impacts and promote resource conservation. It includes composting and recycling of crop residues, animal manure and agricultural chemicals.
- *Water management* embodies installations for producing fresh water, for the treatment of water, wastewater, sewage or sludge, but also technics to improve land water use or availability as well as to control erosion.

On the other hand, FoodTech can be split into the following six sub-domains:

- *Consumer technology* includes kitchen equipment for personal use and services, apps and devices that help users identify and access the best foods, along with providing background information such as recipes, nutrigenomics and food discovery.
- *Delivery services* are continually evolving to offer convenient options for ordering and delivering groceries and ready-to-eat meals to consumers or businesses, utilizing e-commerce, quick commerce (q-commerce) and delivery robotics.
- *Food technology* encompasses equipment and processes for food production, excluding waste management, animal feed and consumer technology.
- *Food chemistry* involves the development of new ingredients and food products, such as alternative proteins, functional foods, beverages and ready-to-eat meals.
- *Food services* are revolutionizing the hospitality industry by incorporating smart equipment and technologies like robotics and cloud kitchens.
- *Supply chain* solutions are being developed to optimize the food supply chain and food retail industry, with a focus on packaging, traceability and food waste management.

Additional details and related search strategies can be found in Appendix B.

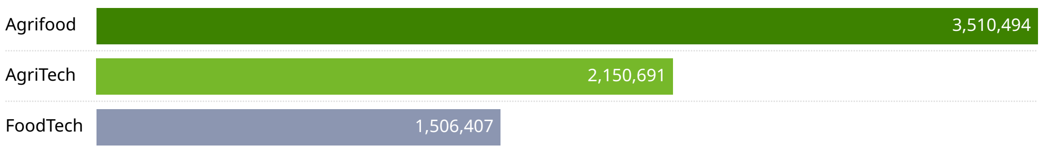
2 Global overview of Agrifood innovations

This chapter begins with an overview of the patent landscape in the AgriTech and FoodTech domains. It then offers an in-depth and comprehensive analysis of the global patent trends, invention origins, top markets for the technologies, and key players within the 17 sub-domains of AgriTech and the six sub-domains of FoodTech.

The Agrifood sector can be divided into two main categories: AgriTech, making up 60% of the total count, and FoodTech, accounting for 40% (Figure 2.1). With over 3.5 million Agrifood inventions (patent families) published over the past 20 years, Agrifood can be considered to be a super-domain.

Agrifood is the conjunction of AgriTech (60% of patent families) and FoodTech (40% of patent families).

Figure 2.1 Number of patent families for Agrifood, AgriTech and FoodTech



Note: The data statistics are based on the number of patent families published since 2004.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Due to the vast size of the overall Agrifood super-domain, the following sections of this report focus on foreign-oriented patent families – also referred to as international patent families or extended patent families – from domestic-only ones.

What is an international patent family?

International patent families are a reliable and neutral proxy for inventive activity because they represent inventions that applicants deem important enough to seek international protection. This serves to highlight innovations with universal application, control for the difference in the propensity to file multiple patent applications for a single invention between patent offices and excludes singletons of very low value while including high-value domestic inventions.[1]

Analysis of the share of international patent families in the Agrifood super-domain shows that only 12% of Agrifood patent families have been extended beyond their original location of first filing. A significant number of non-international patent families originate from Asia, with 82% of

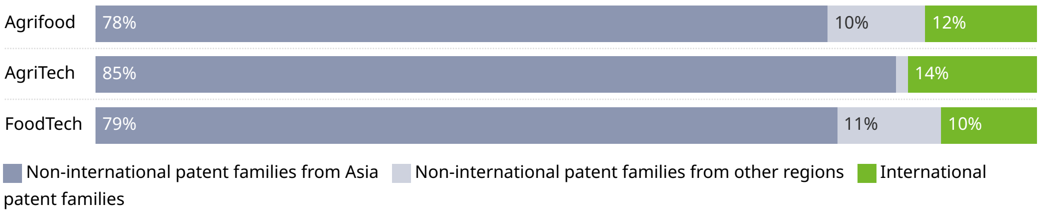
1 Dechezleprêtre, Antoine & Ménière, Yann & Mohnen, Myra, 2017. International patent families: from application strategies to statistical indicators, LSE Research Online Documents on Economics 69486, London School of Economics and Political Science, LSE Library.

the total coming from this region, and the majority of them, 65%, are from China, as illustrated in Figure 2.2.

Utility models have been excluded from the patent analysis in this report because the regional differences and lower inventive threshold for utility models can affect the accuracy and relevance of the analysis. [2] Utility models are not available in all countries and regions, so including them can create inconsistencies in global studies, such as this report, where comparability across countries and regions is essential. The requirements for obtaining a utility model are also less stringent than for a patent and they often cover incremental improvements rather than significant innovations, so including them can dilute the focus on more substantial technological advancements.

Non-international patent families represent 86% of the overall AgriTech domain and 90% in FoodTech.

Figure 2.2 Share of international patent families in Agrifood, AgriTech and FoodTech

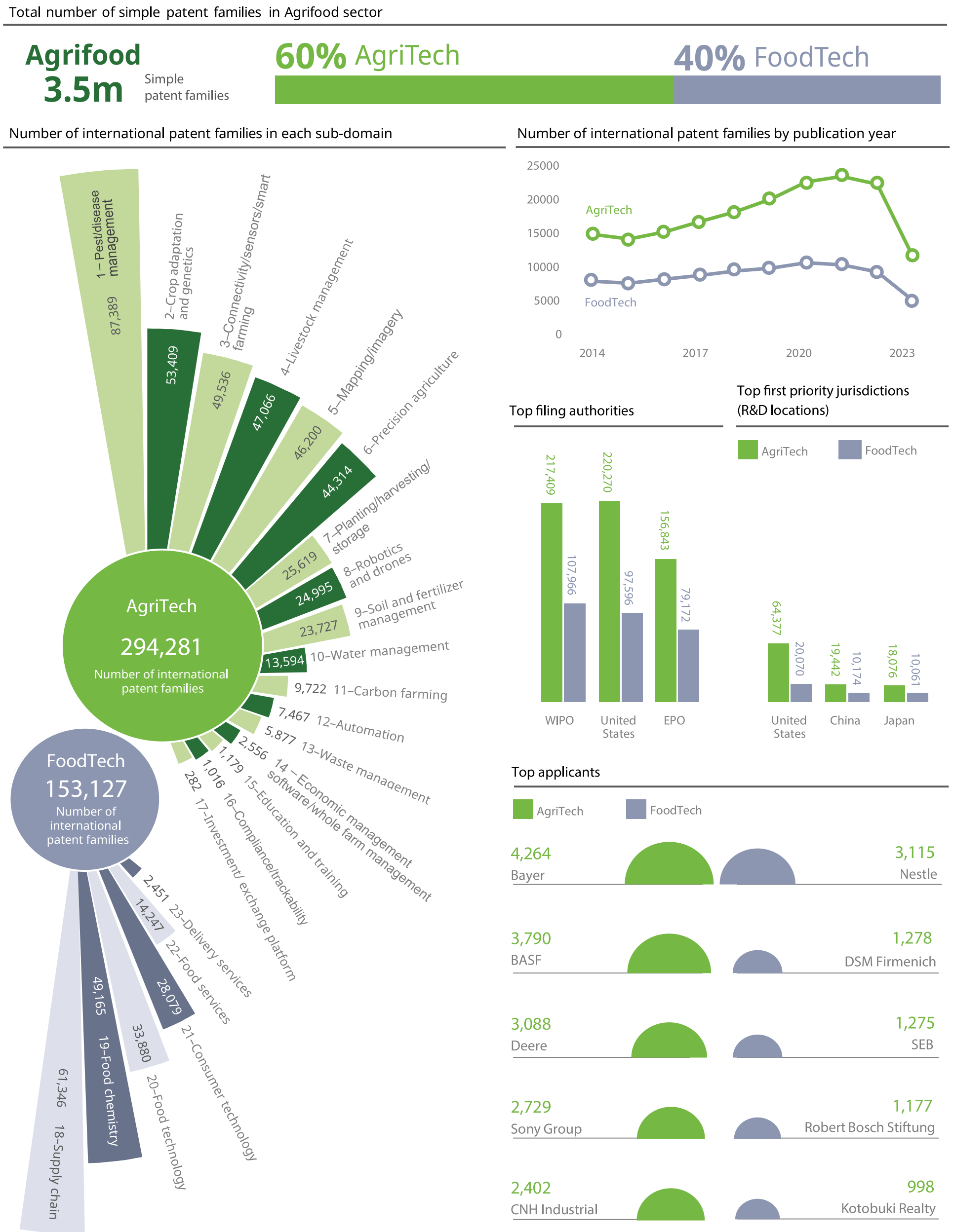


Note: The data statistics are based on the number of patent families published since 2004.
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

2 See https://www.wipo.int/web/patents/topics/utility_models

A snapshot of the patent landscape in Agrifood, highlighting key innovations, dominant regions and top players.

Figure 2.3 An overview of the patent landscape in Agrifood sector



Note: The number of patents in the first row (Agrifood, AgriTech, and FoodTech) is counted as the number of simple patent families. All other data are counted as the number of international patent families. The data covers patents published since 2004.

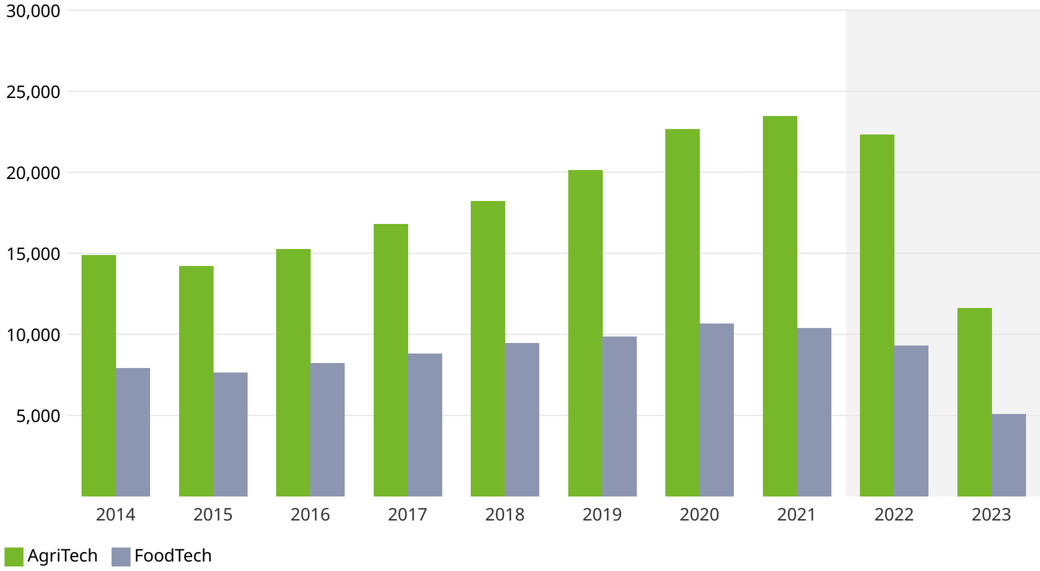
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Agrifood

The 450,000 Agrifood international patent families can be split by 66% on AgriTech (294,281 international patent families) and 34% on FoodTech domains (153,127 international patent families). An examination of the patent publication trend reveals that both AgriTech and FoodTech industries are experiencing a moderate to steady compound annual growth rate (CAGR). AgriTech has a CAGR of 6.9% while FoodTech has a growth rate of 3.3% from 2017 to 2021 (Figure 2.4).

The historical patenting trends show substantial growth in AgriTech but more moderate growth in FoodTech.

Figure 2.4 Number of international patent families by first publication year in AgriTech and FoodTech



Note: Data from 2022 are partial since non-international patent families (singletons) are excluded. 2021 is the last year for which complete data are available.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Publication countries associated to each patent family is a common metric for patent activity because it identifies the geographical area of interest for protection of an invention (Figure 2.5).

In terms of patent filing, Asia leads as the continent with the highest number, with China, Japan, the Republic of Korea and India being the main contributors. Specifically, in the AgriTech sector, China leads with 137,035 international patent families, followed by Japan with 107,709, the Republic of Korea with 64,099 and India with 53,766. In the FoodTech sector, China also leads with 69,023 international patent families, followed by Japan with 53,480, the Republic of Korea with 30,559 and India with 22,434.[3]

Following Asia, North America ranks second in patent filings, with the United States and Canada being the main contributors. In the AgriTech sector, the United States leads with 220,270 international patent families, followed by Canada with 80,414. In the FoodTech sector, the United States leads with 97,596 international patent families, followed by Canada with 37,166.

Europe ranks third in patent filing, with the European Patent Office (EPO), Spain and Germany being the main contributors. In the AgriTech sector, the EPO leads with 156,843 international patent families, followed by Spain with 29,630, and Germany with 27,957. In the FoodTech sector, EPO leads with 79,172 international patent families, followed by Spain with 19,513, and Germany with 16,747.

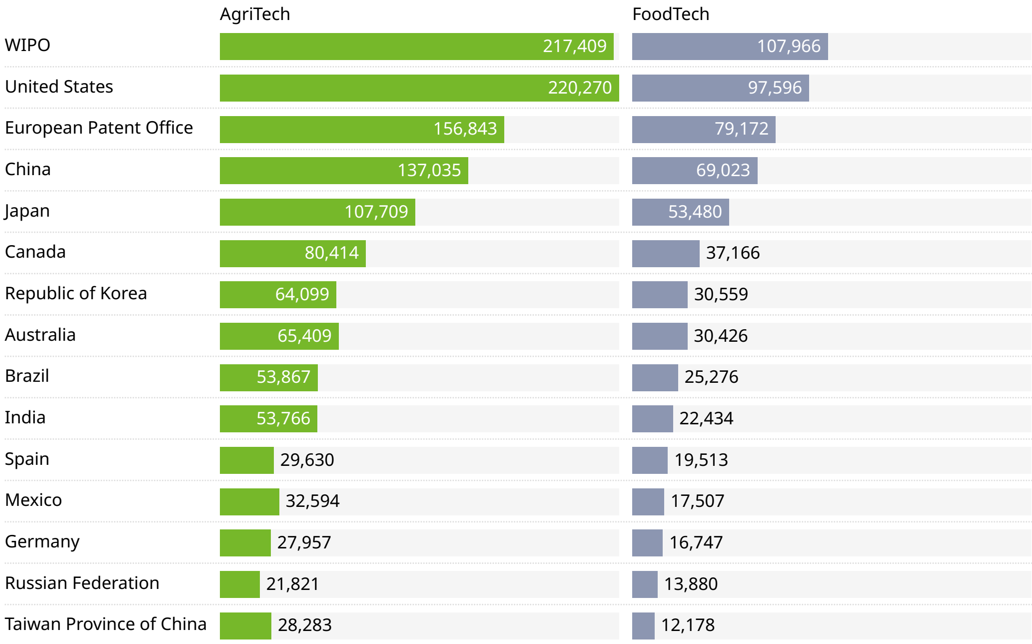
The filing of patent applications in multiple jurisdictions through the WIPO Patent Cooperation Treaty (PCT) pathway[4] has become mainstream. In the AgriTech sector, 73.8% of international patent families, totaling 217,409, were filed through the PCT process. Similarly, in FoodTech, 70.5% of international patent families, amounting to 107,966, were PCT applications.

3 The total number of patents published in each country is much higher than the number of international patent families counted. This is because, when counting international patent families, we count each patent family only once, regardless of how many jurisdictions the patents are published in.

4 See www.wipo.int/pct/en/.

WIPO and the United States are the two major filing authorities of international patent families in AgriTech and FoodTech.

Figure 2.5 Number of international patent families per filing authority in the AgriTech and FoodTech domains



Note: The data statistics are based on the number of international patent families published since 2004.
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

In patent data, the jurisdiction where the first patent application of each patent family was filed can be used as a proxy for the location of R&D, known as the “first priority jurisdiction” (Figure 2.6).

North America, and specifically the United States, has a long history of involvement in the Agrifood super-domain. It has consistently been the main location for R&D in this field over the past decade, with 159,810 international patent families originating from this region. More recently, Japan and China have increased their R&D investments, with 49,679 and 35,091 international patent families respectively. It is important to note that only international patent families were considered in this analysis, which diminishes the impact of regional jurisdictions in Asia.

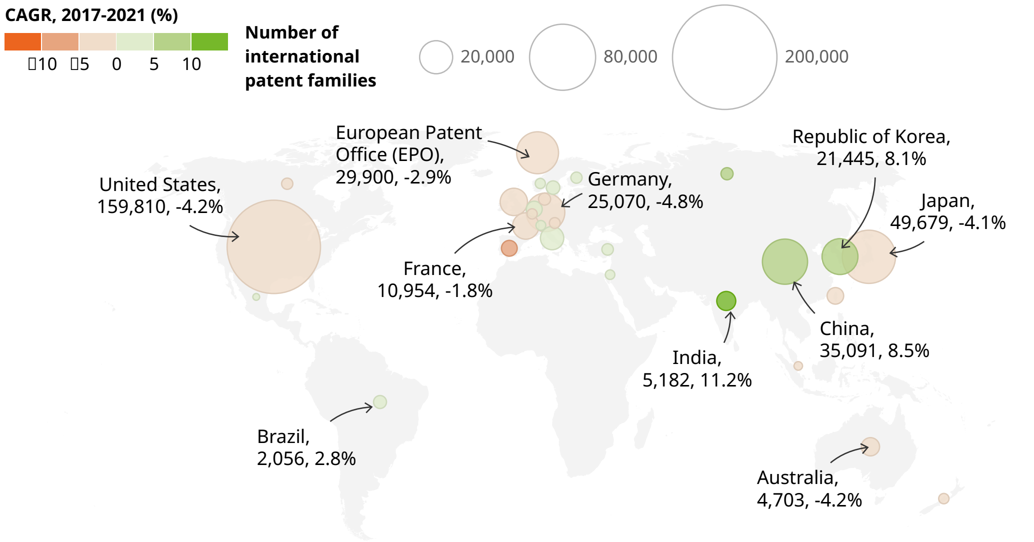
Asia is experiencing rapid growth in this sector, with India and China showing impressive CAGRs of +11.2% and +8.5% respectively from 2017 to 2021. This growth is supported by the ability of Asian authorities to extend their patents globally, with Asia experiencing a CAGR of +3.6% during the same time period.

In contrast, Europe is seeing a modestly negative trend, with the average CAGR for the top 5 jurisdictions being -2.2%. Similarly, North America is also experiencing a decline in growth, with a combined CAGR of -4.1% for the United States and Canada from 2017 to 2021.

In Latin America and the Caribbean, there are a total of 2,388 international patent families related to Agrifood. Among these, 2,056 are from Brazil and 332 from Mexico. The international patent families from this region have been experiencing steady growth, with a CAGR of 3.1% from 2017 to 2021.

The United States is a leader in Agrifood but faces a declines in growth, whereas India and China are experiencing rapid growth.

Figure 2.6 Top first priority jurisdictions (a proxy for R&D location) in Agrifood by number of international patent families



Note: The data statistics are based on the number of international patent families published since 2004.
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

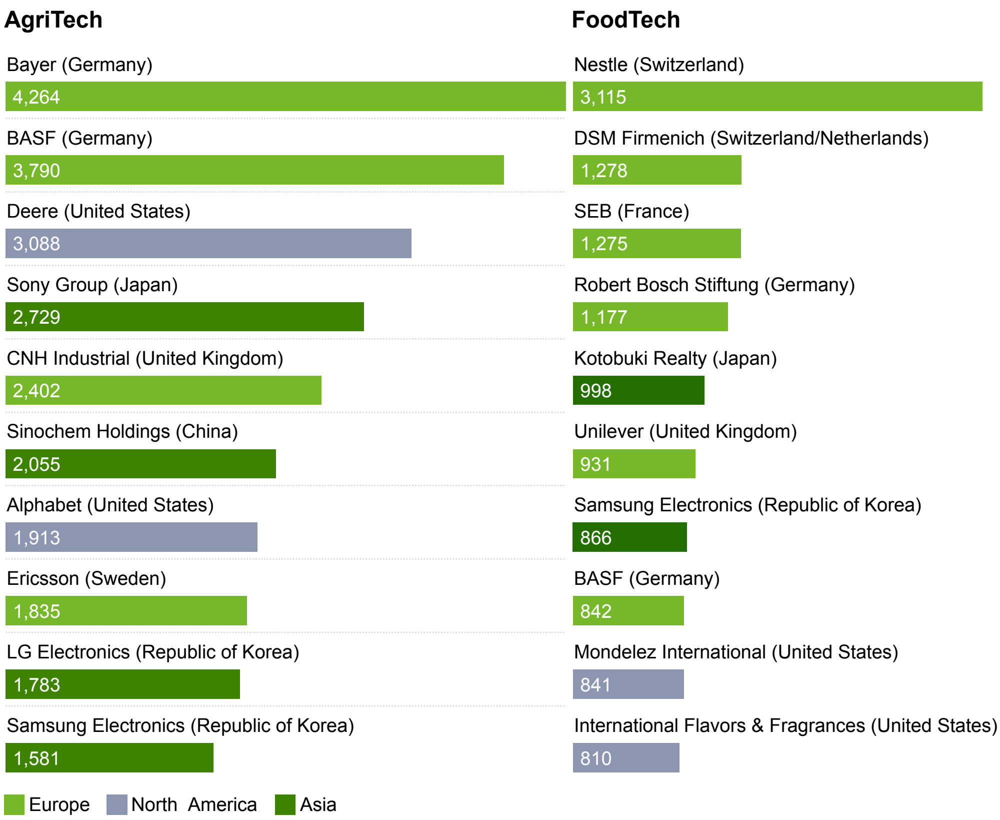
After careful analysis, we were able to identify the key players driving innovation in the Agrifood sector (Figure 2.7). The ranking of patent applicants revealed that the top 10 applicants accounted for a significant 40% of total filings in both AgriTech and FoodTech domains.

In the AgriTech field, innovation is primarily spearheaded by agrochemical companies such as BASF and Bayer from Germany, and Sinochem from China. Additionally, technology giants like Sony, LG and Samsung from Asia, as well as Ericsson from Europe, play a crucial role in driving innovation. Manufacturers of agricultural machinery, including Deere from the United States and CNH Industrial from Europe, are also important contributors to the sector.

On the other hand, the FoodTech sector is heavily dominated by European industries, particularly food and food chemistry companies from Switzerland/Netherlands (Nestlé, DSM-Firmenich), Germany (BASF) and the United Kingdom (Unilever). Major players in the United States such as Mondelez also play a significant role in driving innovation in this sector. Industrial machinery manufacturers from Europe, such as SEB and Robert Bosch Stiftung, and Asia, including Kotobuki Realty and Samsung, are also actively involved in shaping the future of FoodTech.

Innovation in AgriTech is led by large agrochemical companies, tech companies, and agricultural machineries manufacturers, with FoodTech dominated by large food companies.

Figure 2.7 Top applicants in AgriTech and FoodTech



Note: The data statistics are based on the number of international patent families published since 2004.
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Technology at a glance: MEAPLANT – a bioinspired solution for quality food production

MEAPLANT is a new crop cultivation system developed by inventors Dr. Caterina Allera and Enrico Masella. MEAPLANT bridges the gap between traditional soil-based cultivation and advanced soilless techniques.

Dr. Allera, a seasoned researcher at the Italian Council for Research in Agriculture (CREA), embarked on a mission to simplify soilless cultivation. Her journey led her to a critical realization: the complexity of existing systems stemmed from the interaction between cultivation substrates and nutrient solutions. The challenge lay in creating a substrate that could retain water without absorbing it – a delicate balance that is set to revolutionize soilless agriculture.

Nature often holds the key to innovation. Dr. Allera drew inspiration from dewdrops suspended on spider webs, water captured on cactus spines and droplets moving along plant fibers. These natural phenomena, studied for various applications, inspired the birth of MEAPLANT.

MEAPLANT's substrate consists of a mesh of hydrophobic, chemically inert threads. Unlike traditional porous substrates, it doesn't absorb water; instead, it suspends droplets of nutrient solution. The balance between surface tension and gravity keeps these droplets in place, ensuring optimal hydration for plant roots. This water-saving system minimizes evaporation, promotes energy-efficient growth and prevents root asphyxiation. MEAPLANT's recyclable substrate contributes to a negative carbon footprint, making it a sustainable solution for nourishing communities worldwide.

The Italian inventors used WIPO's PCT system (WO2017/195009) to protect their idea globally and they have won a couple of international awards, including the Grand Prix awarded by the French Federation of Inventors (FFI) and the Gold Medal with Special Prize awarded by the Italian Delegation of the 49th International Exhibition of Inventions Geneva in 2024.

Figure 2.8 MEAPLANT in action

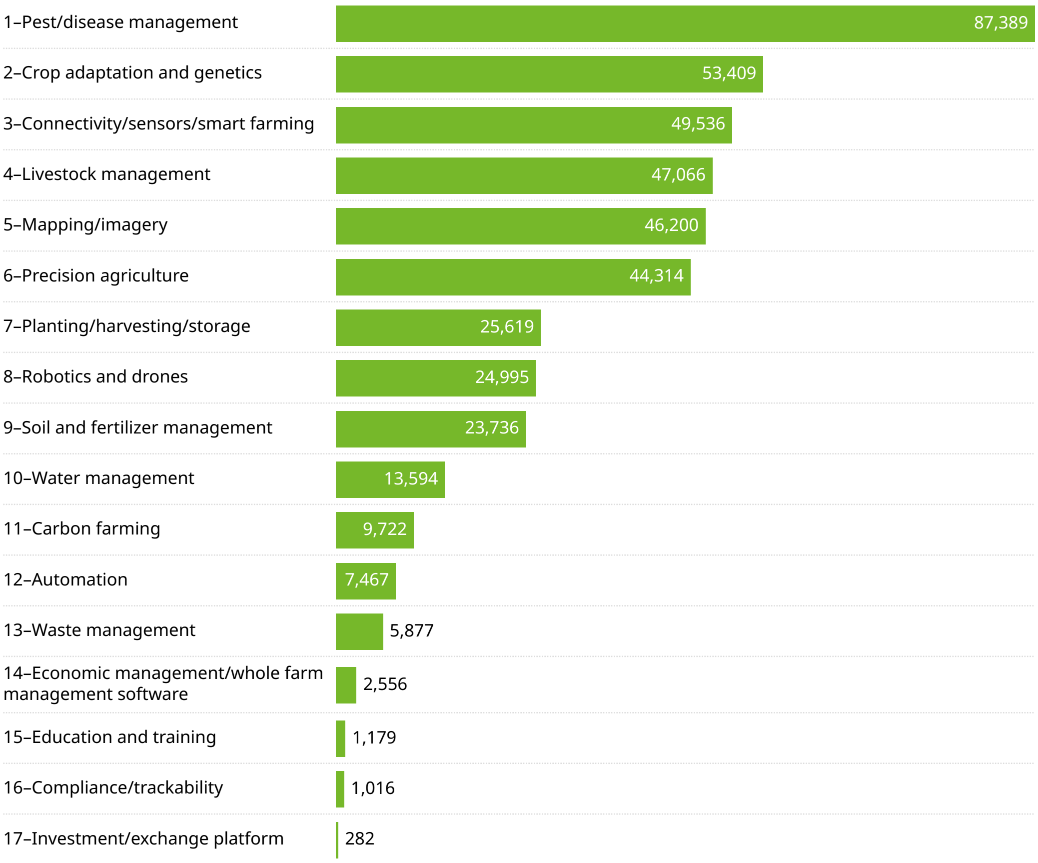
Source: MEAPLANT

AgriTech

Analyzing the volume of patenting activity related to the individual AgriTech sub-domains reveals that over the last two decades, the sub-domains within AgriTech that has seen the most research and investigation is *Pest/disease management*. Following closely behind are *Crop adaptation and genetics, Livestock management*, and IoT-related sub-domains such as *Connectivity/sensors/smart farming, Precision agriculture* and *Mapping/imagery*.

Additionally, the areas of *Planting/harvesting/storage, Robotics and drones*, and *Soil and fertilizer management* have also seen a plethora of innovations since 2004. This general observation makes it difficult to directly detect any specific trends regarding the dynamic of AgriTech sub-domains by simply looking at the overall volume of innovations (Figure 2.9).

Pest/disease management is the most popular sub-domain for patenting in AgriTech.
Figure 2.9 Number of international patent families in AgriTech sub-domains

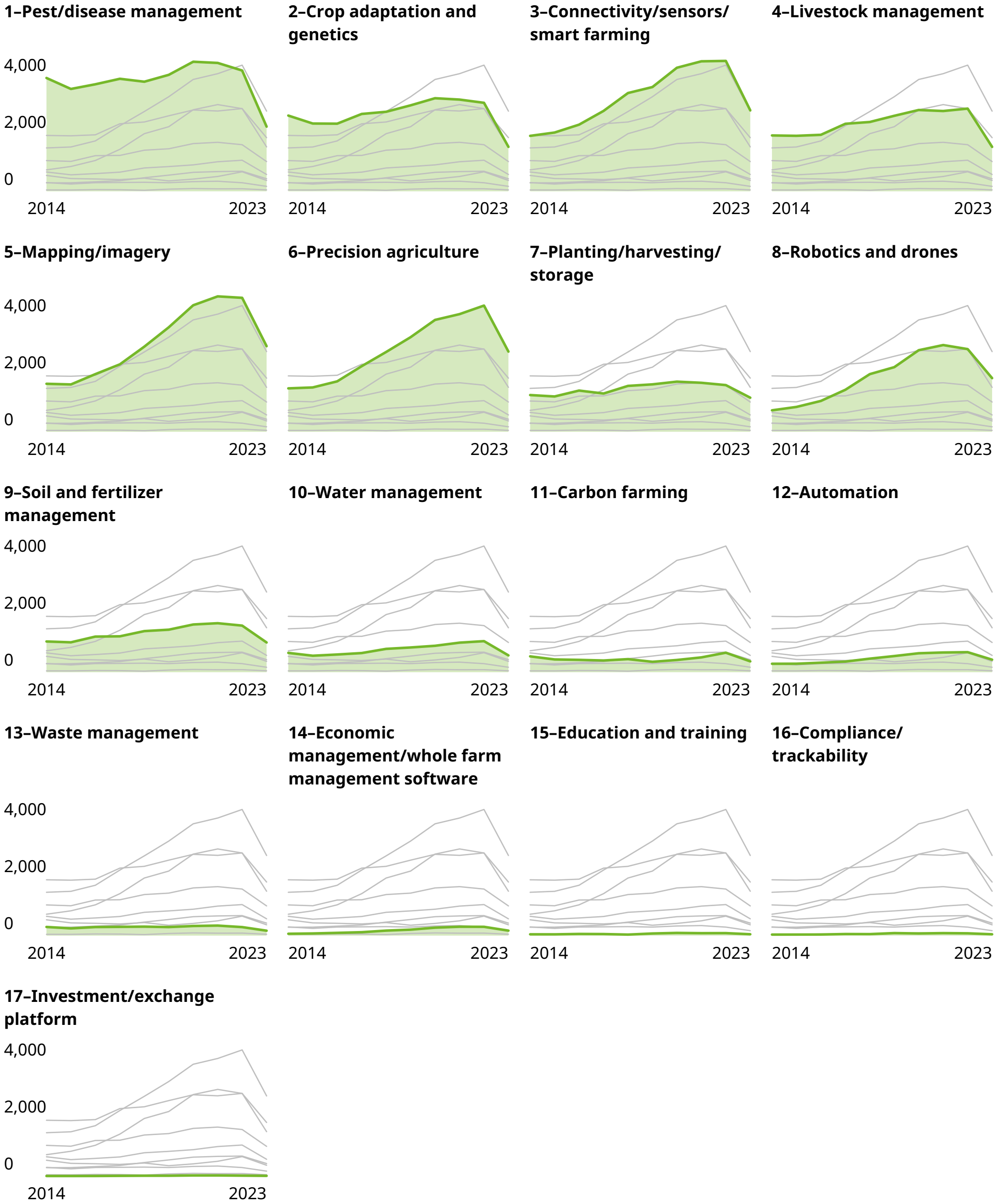


Note: The data statistics are based on the number of international patent families published since 2004.
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Upon conducting a thorough analysis of patent publications, it becomes evident that each of the 17 AgriTech sub-domains possesses a unique profile. Specifically, the sub-domains of *Investment/exchange platform* and *Economic management/whole farm management software* both exhibit a CAGR of +21%. In contrast, both *Robotics and drones* and *Mapping/imagery* experienced a slightly lower CAGR of +15% during the same period. then *Automation* and *Precision agriculture* are up to +12% for a CAGR calculated in the same period. The growth rates of the above-mentioned sub-domains are quite significant when compared to the overall average CAGR of 6.9% across the broader AgriTech domain. This significant growth trend can be attributed to the increasing interest in IoT technologies that are designed to automate various tasks throughout the agricultural value chain (Figure 2.10).

Significant progress has been made in investments related to IoT-related technologies including Precision agriculture, Mapping/imagery, Connectivity/sensors/smart farming, Robotics and drones.

Figure 2.10 Number of international patent families by first publication year in AgriTech sub-domains



Note: Data from 2022 are partial since non-international patent families are excluded. 2021 is the last year for which complete data are available.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

From the comparison of top priority jurisdictions and top protection jurisdictions across AgriTech's 17 sub-domains, it is evident that the international patent families related to these technologies primarily originate from the United States, Europe, China, Japan and the Republic of Korea. International patent families from these five regions account for 67–89% of all international patent families in the various AgriTech sub-domains. Conversely, patents granted in these regions constitute 30–55% of all granted patents in the field globally. This indicates that while innovation predominantly originates in these five regions, patents are subsequently secured in a broader range of markets worldwide (Figure 2.11).

In all AgriTech sub-domains, the United States is the main location regarding each sub-domain, with more than 30% of patent corpuses associated as first priority, being up to 50% for *Precision agriculture, Mapping/imagery, Investment/exchange platform*.

Asia, including China, Japan or the Republic of Korea, are found second regarding the majority of the AgriTech sub-domains.

Japan is the second inventor location for IoT-related technologies, including:

– *Mapping/imagery*
– *Precision agriculture*
– *Robotics and drones*
– *Connectivity/sensors/smart farming*
– *Economic management/whole farm management software*
– *Livestock management*
– *Carbon farming.*

China is second worldwide for:

– *Automation*
– *Education and training*
– *Investment/exchange platform*
– *Waste management*
– *Water management.*

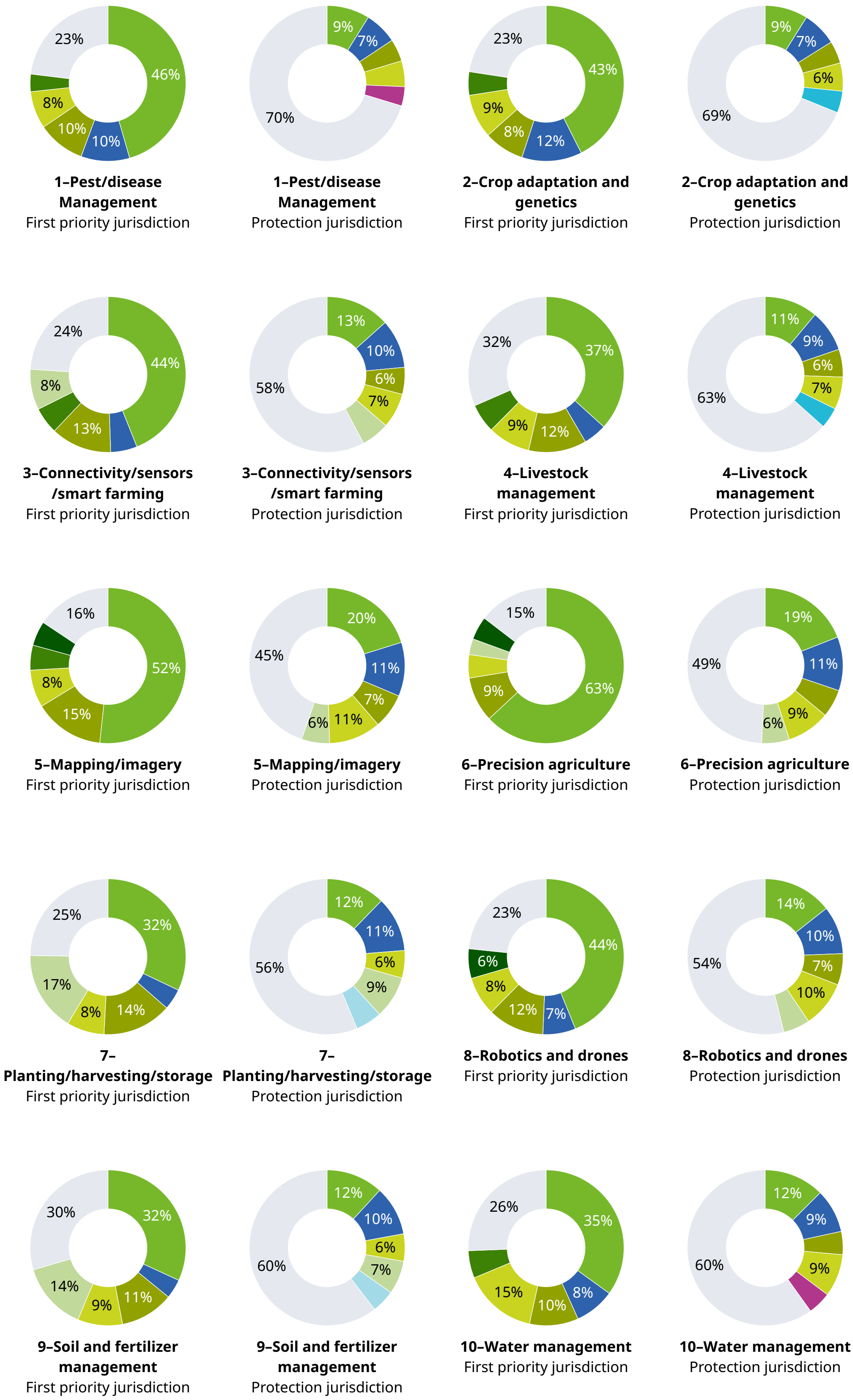
The Republic of Korea is second worldwide for its impact on innovation related to:

– *Compliance/trackability.*

The European Patent Office (EPO) and Germany are also key jurisdictions for AgriTech innovations, being second worldwide for sub-domains related to fields historically related to agriculture, including *Crop adaptation and genetics, Pest/disease management, Planting/ Harvesting/Storage, Soil and fertilizer management*.

The United States is the most popular office of first filing for international AgriTech patent families.

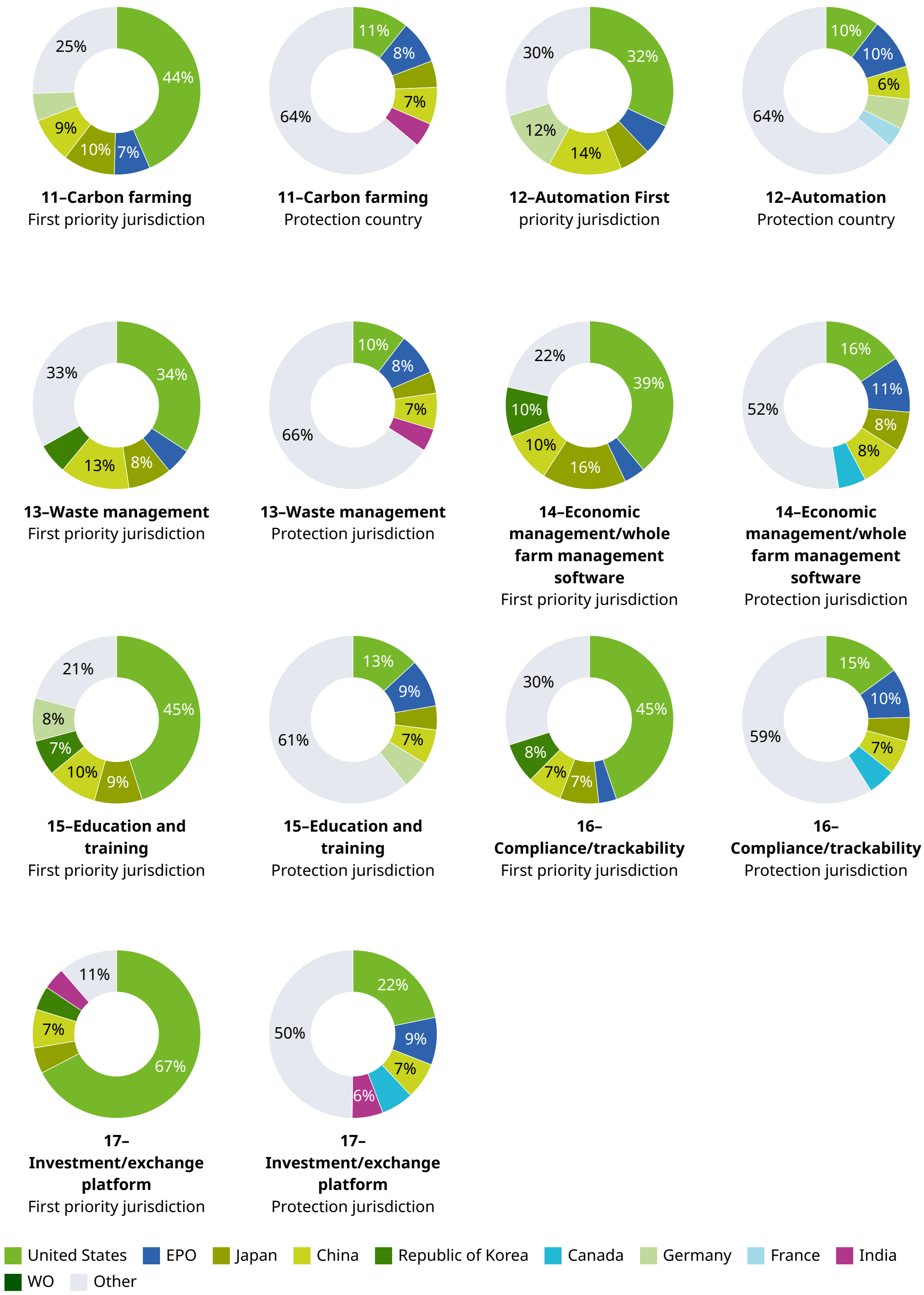
Figure 2.11 The top five first priority jurisdictions and top five protection jurisdictions in each AgriTech sub-domain by number of international patent families



Note: The data statistics are based on the number of international patent families published since 2004. In each pie chart, only data from the top five jurisdictions are displayed; all other jurisdictions are grouped under "Other." Due to variations in the top first priority jurisdictions and the top protection jurisdictions across each sub-domain, the composition of "Other" jurisdictions also varies.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Figure 2.11 The top five first priority jurisdictions and top five protection jurisdictions in each AgriTech sub-domain by number of international patent families – continued

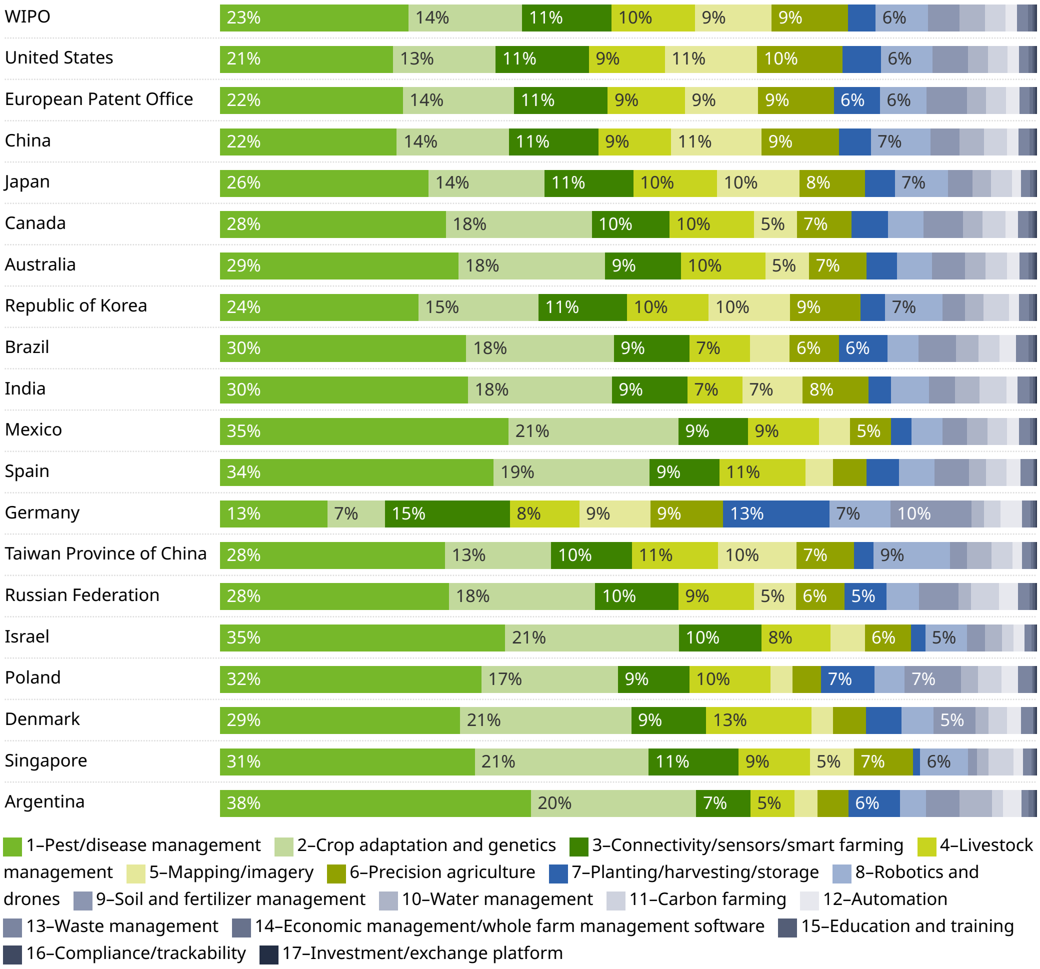


It is crucial to analyze the top filing authorities in order to gain a deeper understanding of the key markets associated with AgriTech sub-domains (Figure 2.12).

Upon examination, it becomes clear that the main filing authorities share similar profiles, with *Pest/disease management* and *Crop adaptation and genetics* being the two major areas represented in each jurisdiction. However, Germany stands out as having a distinct profile, focusing on *Connectivity/sensors/smart farming* innovations. This particular sub-domain ranks third in top authorities worldwide, with the exception of Canada, Australia, Mexico, Spain, Taiwan Province of China, Poland and Denmark, which are primarily targeted by innovations in *Livestock management*. These jurisdictions are major meat exporters globally, highlighting the specific market demands within each region.

Most of the main filing authorities share similar profiles, with significant representation in Pest/disease management and Crop adaptation and genetics.

Figure 2.12 The technical field distribution of international patent families filed in the top filing authorities in AgriTech



Note: The data statistics are based on the number of international patent families published since 2004.
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Breaking down the AgriTech domain into 17 sub-domains allows for a more precise identification of the specific areas of interest for key players in this industry. By examining the top 5 patent applicants in each sub-domain, we can see that each sub-domain has its own unique characteristics and leading companies (Figure 2.13).

Industrial manufacturers of agricultural machines from the United States (Deere, CLAAS), Japan (Kubota) and Europe (CNH Industrials) are leading most of the sub-domains, being within the top 5 categories as follows:

- *Automation, Connectivity/sensors/smart farming* (Deere, CLAAS, CNH Industrials)
- *Mapping/imagery* (Deere only)
- *Pest/disease management, Planting/harvesting/storage, Precision agriculture* (Deere only)
- *Soil and fertilizer management* (Deere, Kubota, CNH Industrials)
- *Education and training* (excluding CNH Industrials)
- *Economic management/whole farm management software* (excluding CNH Industrials).

Agrochemical companies from Germany (BASF, Bayer), China (Sinochem) and Japan (Sumitomo) lead in the related Agrochemical sub-domains, including:

- *Crop adaptation and genetics*
- *Pest/disease management*
- *Water management,* and

- *Economic management/whole farm management software* (excluding Sinochem and Sumitomo).

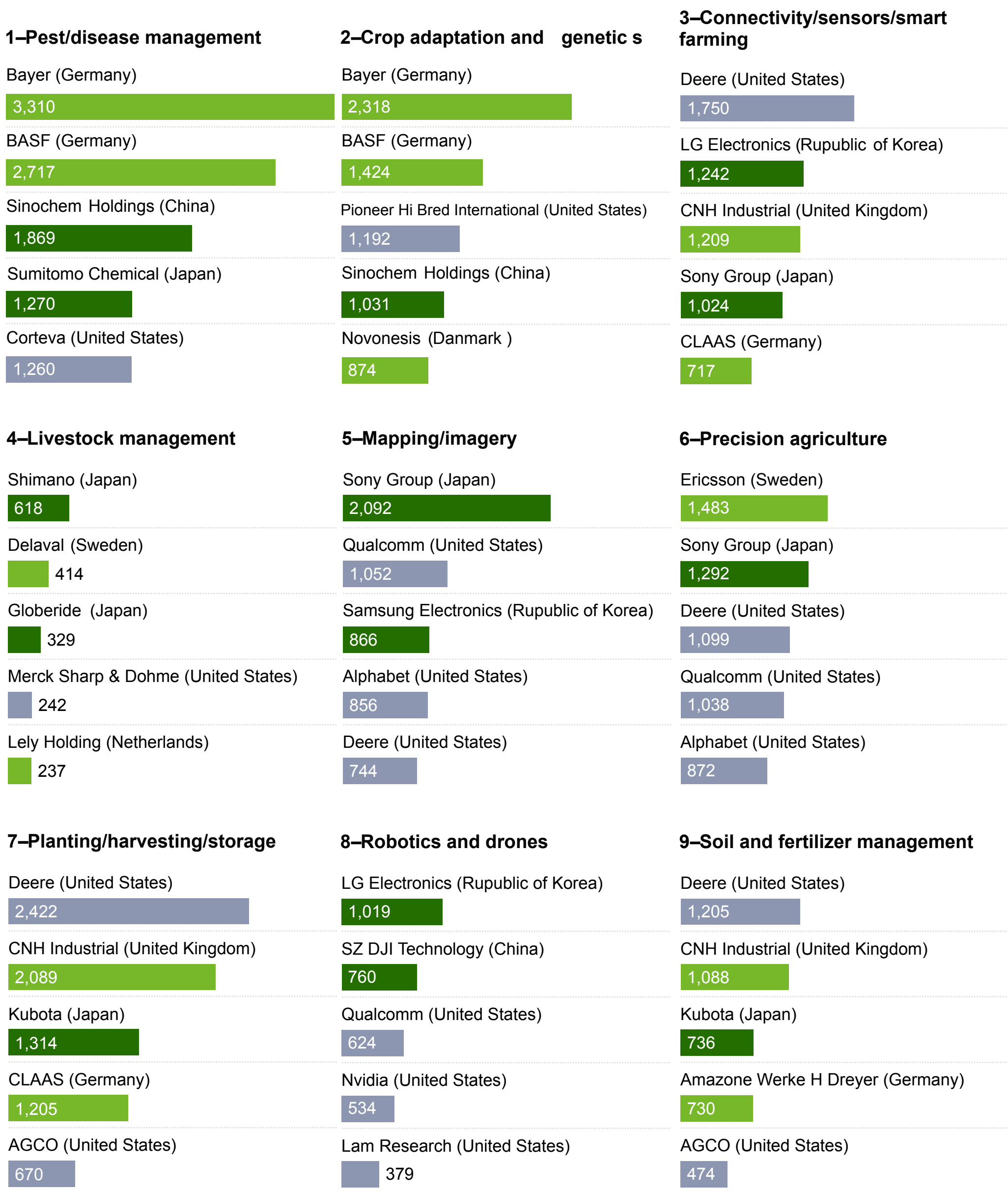
Asian Companies from the tech domain (Sony, LG Electronics, Samsung, Qualcomm, Ericsson, Nvidia) are usually found within the top 5 of IoT-related sub-domains, such as:

- *Connectivity/sensors/smart farming* (Sony and LG Electronics)
- *Mapping/imagery* (Sony, Qualcomm, Samsung)
- *Precision agriculture* (Sony, Qualcomm, Ericsson)
- *Robotics and drones* (Nvidia, LG Electronics and Qualcomm).

Finally, Carbon farming and Livestock management encompass distinct top players specialized in this field.

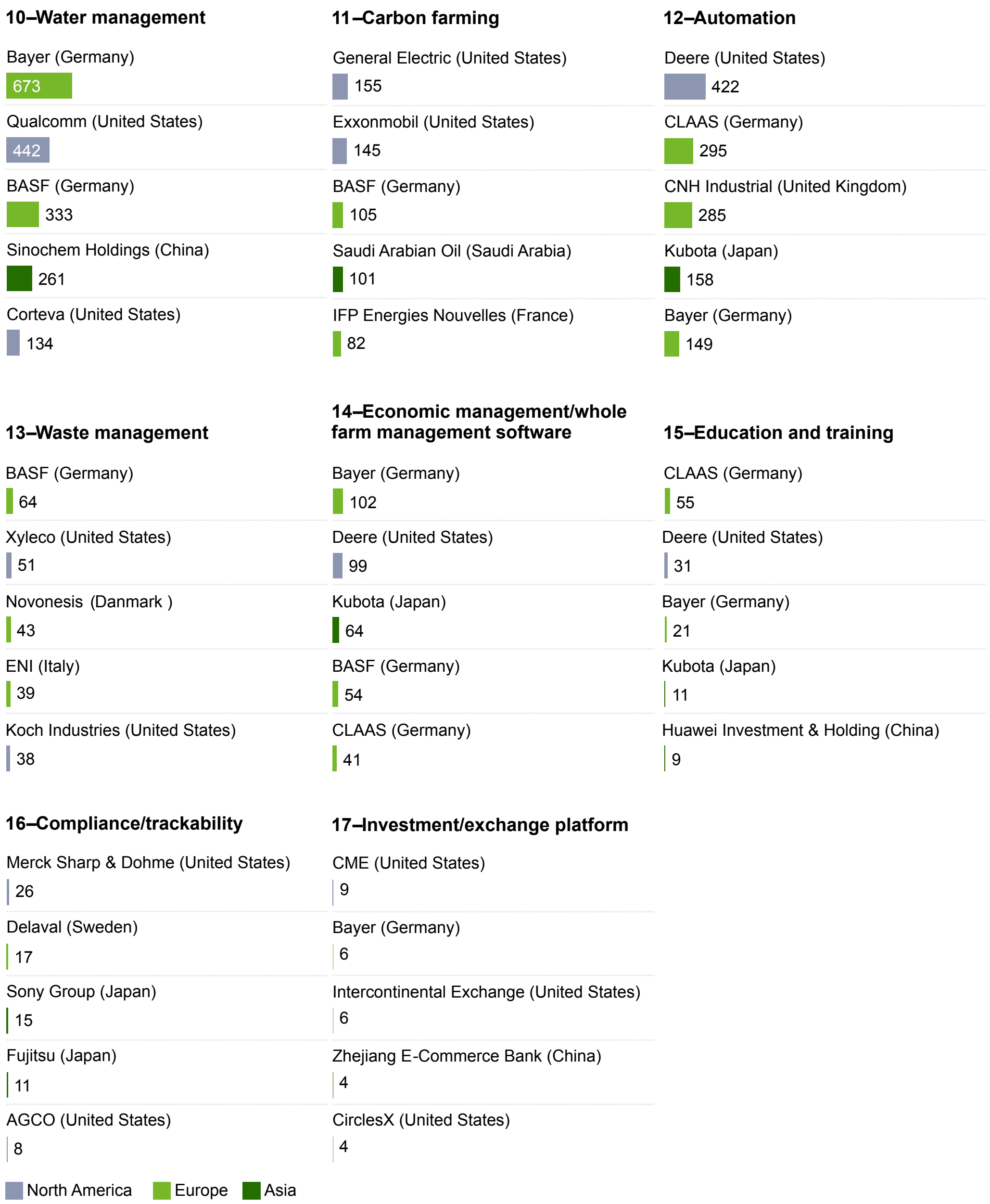
Industrial manufacturers lead in Automation, and Precision agriculture, agrochemical companies in Crop adaptation and genetics and Pest/disease management, and tech companies in IoT sub-domains like Connectivity/sensors/smart farming and Mapping/imagery.

Figure 2.13 Top 5 applicants in each sub-domain of AgriTech



Note: The data statistics are based on the number of international patent families published since 2004.
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Figure 2.13 Top 5 applicants in each sub-domain of AgriTech - continued

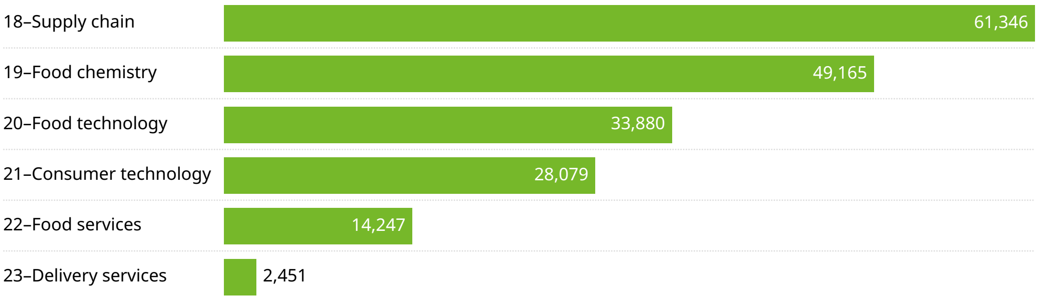


FoodTech

An analysis of patent volumes within various sub-domains of FoodTech over the past 20 years shows that *Supply chain* has been the most extensively researched area with more than 60,000 international patent families already filed internationally. This is followed by Food chemistry encompassing close to 50,000 international patent families. *Food technology* and *Consumer technology* are both close to 30,000 international patent families. *Food services* have nearly 15,000 international patent families. Furthermore, *Delivery services* complete our ranking with nearly 2,500 international patent families (Figure 2.14).

Supply chain is the most popular sub-domain for patenting in FoodTech, followed by Food chemistry and Food technology.

Figure 2.14 Number of international patent families in FoodTech sub-domains

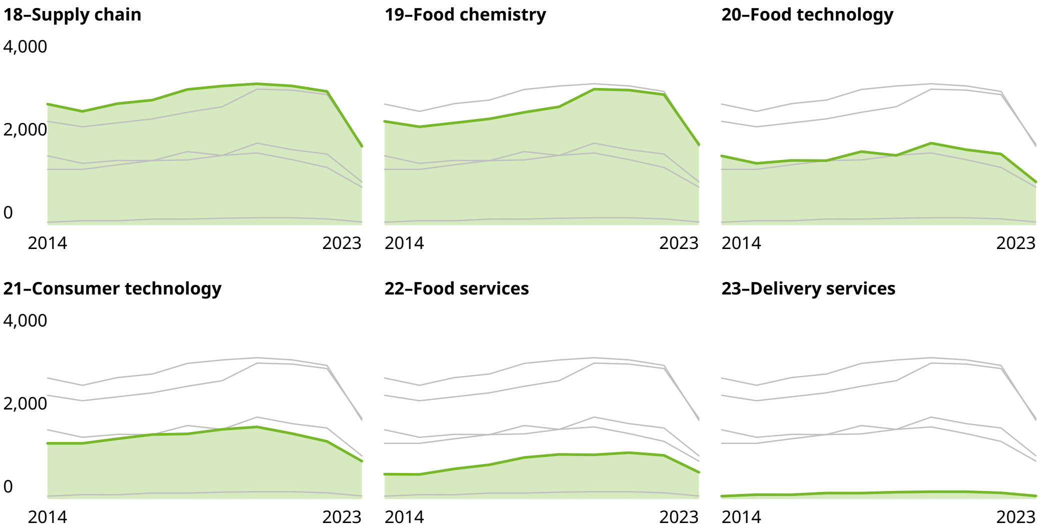


Note: The data statistics are based on the number of international patent families published since 2004.
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

In contrast to the rapid growth seen in AgriTech, the sub-domains within FoodTech have experienced relatively stagnant growth over the past decade. The CAGR for the industry as a whole has been close to 3% from 2017 to 2021, indicating a lack of significant investment in these areas (Figure 2.15). However, it is worth noting that certain sub-domains, such as *Food chemistry* and *Food services*, have shown a stronger growth trajectory. These specific areas have achieved a CAGR of +5% and +6% respectively during the same period. This trend aligns with the current focus of food companies on developing *alternative nutrient sources for human food*, a topic that will be explored in more detail in a subsequent paragraph.

The overall growth of FoodTech sub-domains has been relatively stagnant over the past decade, except for the significant growth seen in Food chemistry and Food services.

Figure 2.15 Number of international patent families by first publication year in FoodTech sub-domains



Note: Data from 2022 are partial since non-internatioanl patent families are excluded. 2021 is the last year for which complete data are available.
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

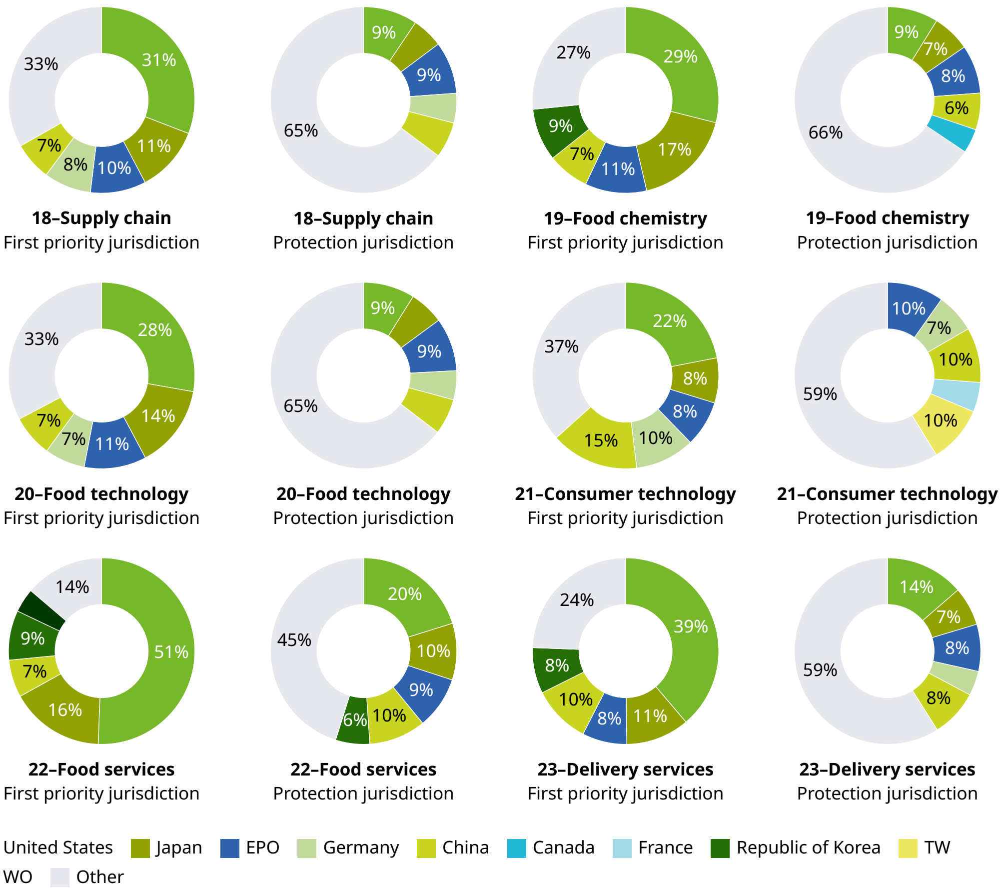
R&D locations for each sub-domain within the FoodTech industry can be identified through an analysis of the number of international patent families in first priority jurisdictions (Figure 2.16). The United States is seen as the primary location for sub-domains such as *Food services*, and *Delivery services*. However, its dominance is less pronounced in *Food chemistry, Food technology*, and *Consumer technology* sub-domains.

Asian countries including Japan, China and the Republic of Korea emerge as the second most important locations for the majority of FoodTech sub-domains.

The EPO and Germany also play a significant role in FoodTech innovation.

The United States is generally the most popular location for FoodTech R&D, although Asia and Europe play key roles in some more specific areas.

Figure 2.16 The top five first priority jurisdictions and top five protection jurisdictions in each FoodTech sub-domain by number of international patent families



Note: The data statistics are based on the number of international patent families published since 2004. In each pie chart, only data from the top five jurisdictions are displayed; all other jurisdictions are grouped under "Other." Due to variations in the top first priority jurisdictions and the top protection jurisdictions across each sub-domain, the composition of "Other" jurisdictions also varies.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

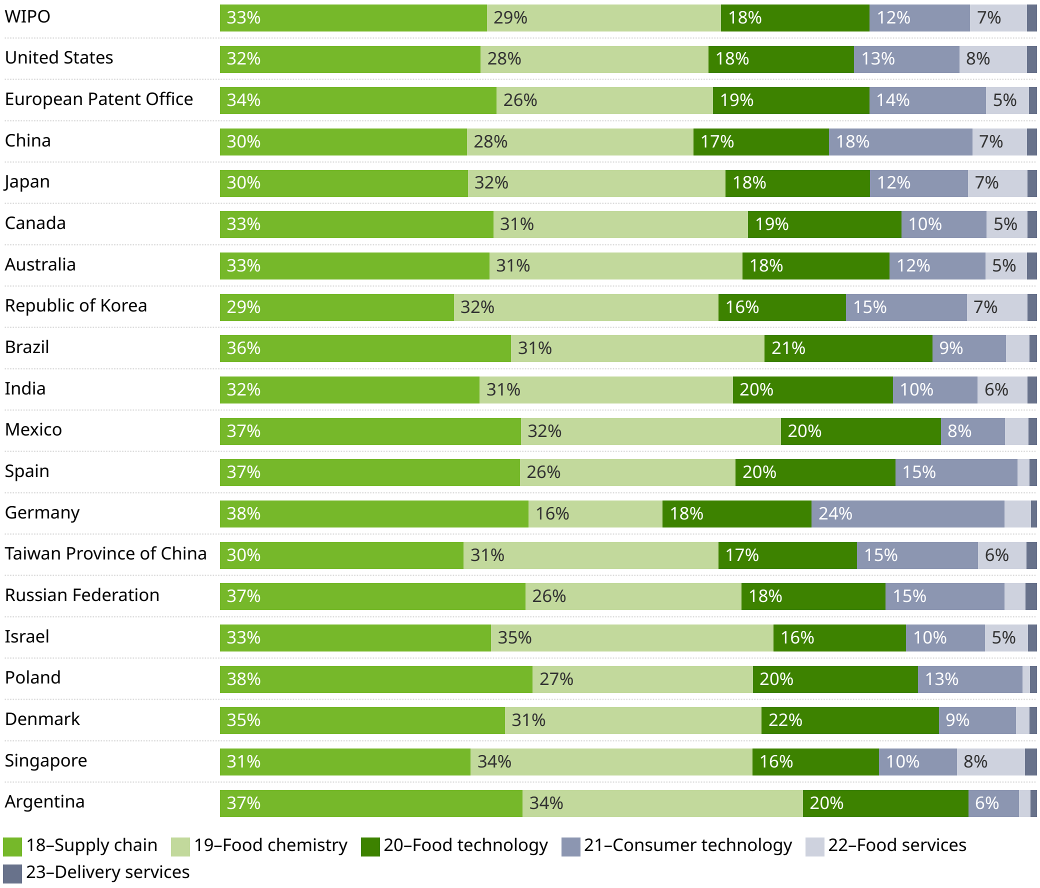
In order to gain a deeper understanding of the key markets within the FoodTech sub-domains, it is essential to analyze the top filing authorities (Figure 2.17). When examining the main filing authorities, it becomes evident that they share similar profiles, with *Supply chain, Food chemistry* and *Food technology* being the most prevalent in each jurisdiction.

However, *Food chemistry* is ranked first for Asian jurisdictions including Japan, the Republic of Korea, Singapore and Taiwan Province of China. This result is in line with the current position of Asia as key bio-ingredient production base worldwide.[5] Additionally, it is of note that *Food chemistry* also ranked first for Israel, which is currently developing new *alternative nutrient sources for human food*. This specific topic will be further explored in chapter 5.

5 Will Asia Play a Central Role in Sustainable Agrifood Biotech? (https://milkeninstitute.org/article/asia-sustainable-agrifood-biotech-play-central-role).

The common key markets in FoodTech are Supply chain, Food technology and Consumer technology.

Figure 2.17 The technical field distribution of international patent families filed in the top filing authorities in FoodTech



Note: The data statistics are based on the number of international patent families published since 2004.
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

By breaking down the FoodTech domain into six sub-domains, we are able to more accurately pinpoint the specific areas of interest for key players within the industry. When analyzing the top 5 patent applicants within each sub-domain, we can observe that each sub-domain possesses its own distinct characteristics and is led by different companies (Figure 2.18).

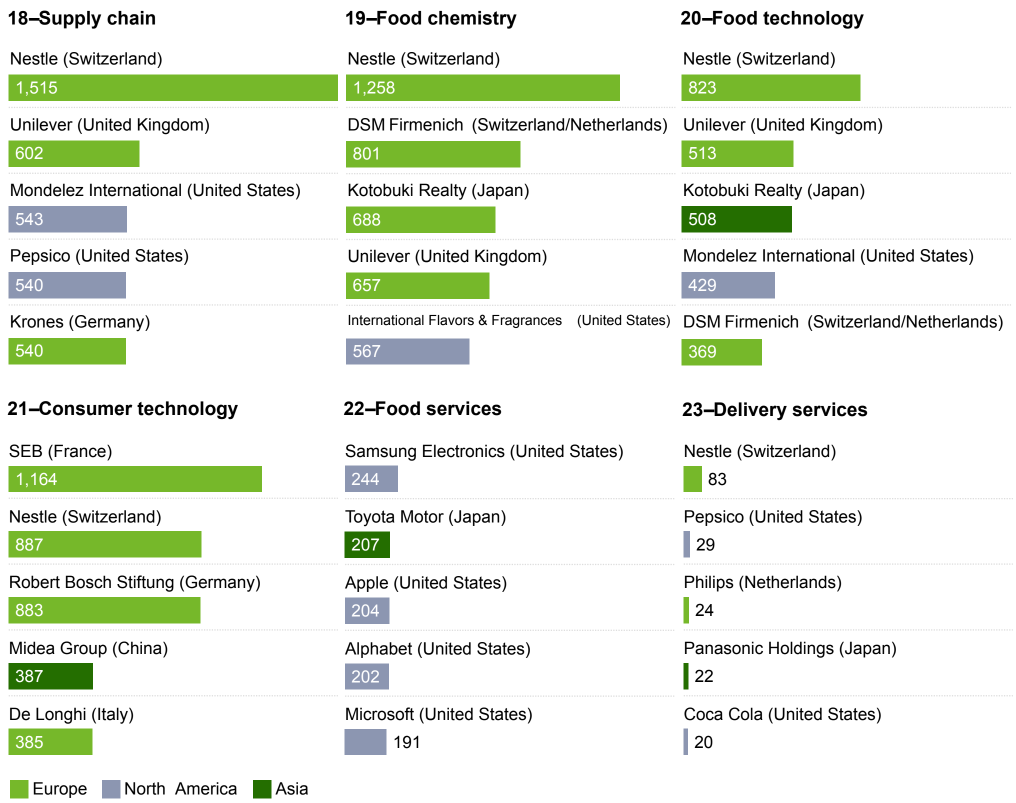
For instance, the *Food chemistry* sub-domain is primarily controlled by major multinational food and nutrition corporations such as Nestlé from Switzerland, DSM-Firmenich from Switzerland/Netherlands, International Flavors & Fragrances from the United States, as well as Consumer Goods companies such as Kotobuki Realty from Japan and Unilever from the United Kingdom.

On the other hand, the Food services sub-domain is dominated by technology companies from the United States (such as Microsoft, Alphabet – owner of Google, and Apple) and the Republic of Korea (such as Samsung).

Interestingly, Nestlé emerges as a significant player in the FoodTech industry, leading in all sub-domains except for Food services.

Multinational food/nutrition corporations dominate Food chemistry, whereas tech companies lead in Food services.

Figure 2.18 Top 5 applicants in each sub-domain of FoodTech



Note: The data statistics are based on the number of international patent families published since 2004.
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Plant variety protection under the UPOV Convention

Patents and plant varieties represent distinct forms of intellectual property that both play crucial roles in fostering innovation within the Agrifood sector. While patents provide protection for novel inventions and technological advancements, granting exclusive rights to inventors for a specific period, plant variety protection provide rights to breeders of new, distinct, uniform, and stable plant varieties, during the term of protection. This patent landscape report on Agrifood focuses exclusively on patents, highlighting technological progress, yet it is essential to recognize that plant variety protection also significantly contribute to agricultural innovation by encouraging the development of new plant breeds, which are vital for food security, sustainability, and adaptation to changing environmental conditions.

New plant varieties: delivering solutions to farmers, growers and society

New, improved varieties of plants are an important and sustainable means of achieving food security in the context of population growth and climate change. New varieties that are adapted to the environment in which they are grown increase the choice of healthy, tasty and nutritious food while generating a viable income for farmers.

Promoting the development of new plant varieties: the UPOV system

The International Union for the Protection of New Varieties of Plants (UPOV) is an intergovernmental organization based in Geneva, Switzerland. UPOV was established in 1961 by the International Convention for the Protection of New Varieties of Plants (the "UPOV Convention"). The mission of UPOV is to provide and promote an effective system of plant variety protection, with the aim of encouraging the development of new varieties of plants, for the benefit of society.

Most countries and intergovernmental organizations which have introduced a plant variety protection (PVP) system have chosen to base their system on the UPOV Convention to provide an effective, internationally recognized system.[6] As of February 2, 2024, (i) UPOV has 79 members, (ii) 18 States and 1 intergovernmental organization have initiated the procedure for acceding to the UPOV Convention, and (iii) 25 States and 1 intergovernmental organization have been in contact with the Office of the Union for assistance in the development of laws based on the UPOV Convention.

Filing applications for PVP

The UPOV Convention provides the basis for UPOV members to encourage plant breeding by granting breeders of new plant varieties an intellectual property right: the breeder's right. In order to obtain protection, the breeder needs to file individual applications with the authorities of UPOV members entrusted with the task of granting breeders' rights.[7]

The UPOV Convention specifies the acts that require the breeder's authorization in respect of the propagating material of a protected variety and, under certain conditions, in respect of the harvested material. Under the UPOV Convention, the breeder's right is only granted where the variety is (i) new, (ii) distinct, (iii) uniform, (iv) stable and has a suitable denomination. The breeder's right does not extend to acts done (i) privately and for non-commercial purposes, (ii) for experimental purposes and (iii) for the purpose of breeding other varieties. Under the UPOV Convention, acts done for the purpose of breeding other varieties are not subject to any restriction by the breeder of a protected variety.

Becoming a UPOV member

A state or intergovernmental organization that wishes to become a UPOV member needs to seek the advice of the UPOV Council in respect of the conformity of its laws with the provisions of the UPOV Convention. This procedure leads, in itself, to a high degree of harmony in those laws, thus facilitating cooperation between members in the implementation of the system. Guidance documents on how to develop legislation and become a UPOV member can be found on the UPOV website.[8] The legislation of UPOV members can be consulted in UPOV Lex.[9]

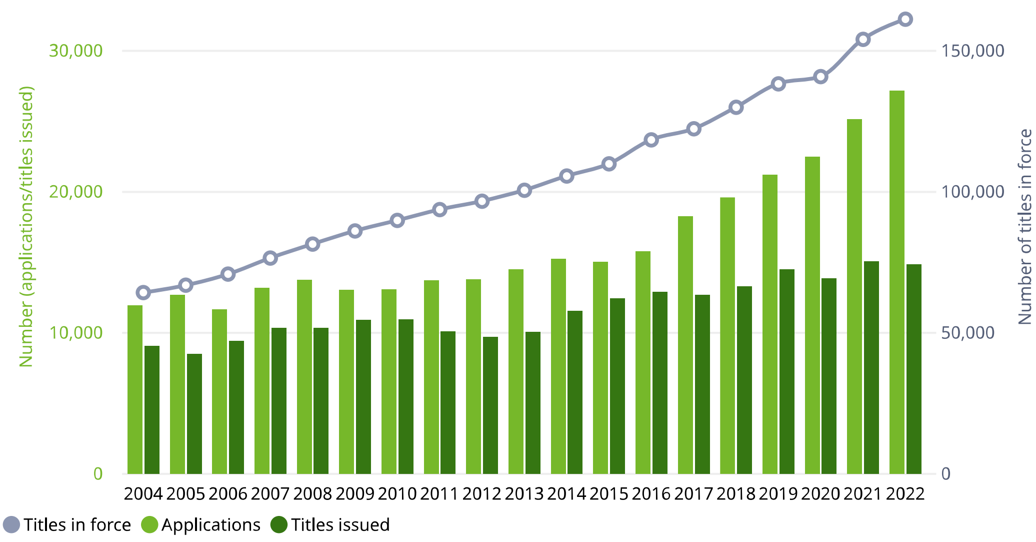
Trends and statistics

The number of applications for PVP in UPOV members has been steadily increasing over the past years. Figure 2.19 indicates trends in applications filed (over 27,000 in 2022) and total number of titles in force (over 160,000 worldwide). Information is also provided on the top 10 UPOV members receiving the largest number of applications in 2012, 2021 and 2022 (Figure 2.20) and an analysis of applications by residence of applicants for the same years (Figure 2.21).

6 See www.upov.int/members/en/.
7 See www.upov.int/members/en/pvp_offices.html.
8 See www.upov.int/members/en/upov_membership.html.
9 See https://upovlex.upov.int/en/legislation.

The number of PVP applications and the total number of titles in force among UPOV members have been steadily increasing.

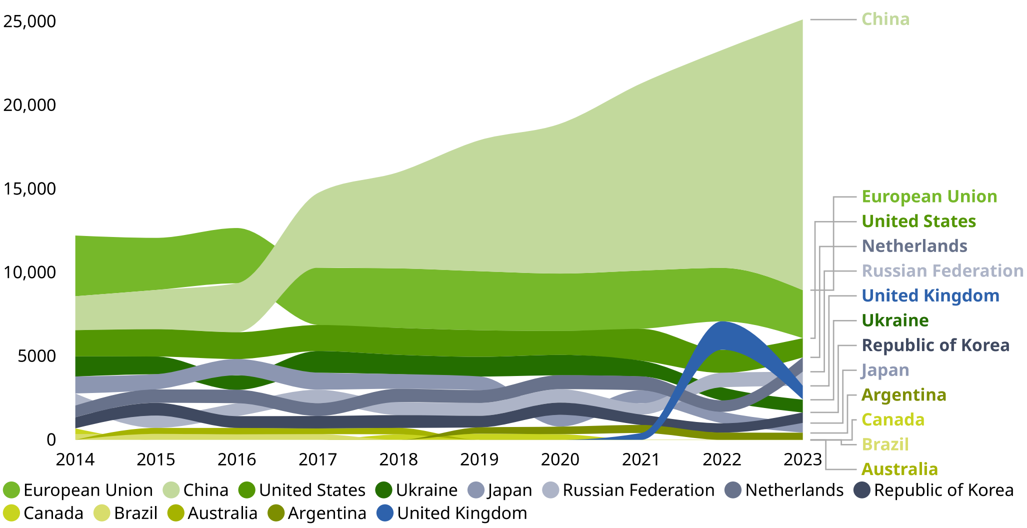
Figure 2.19 Total applications filed, titles issued and titles in force



Source: UPOV.

In contrast to the patent landscape, the main countries receiving PVP applications include the Netherlands, Ukraine and Argentina.

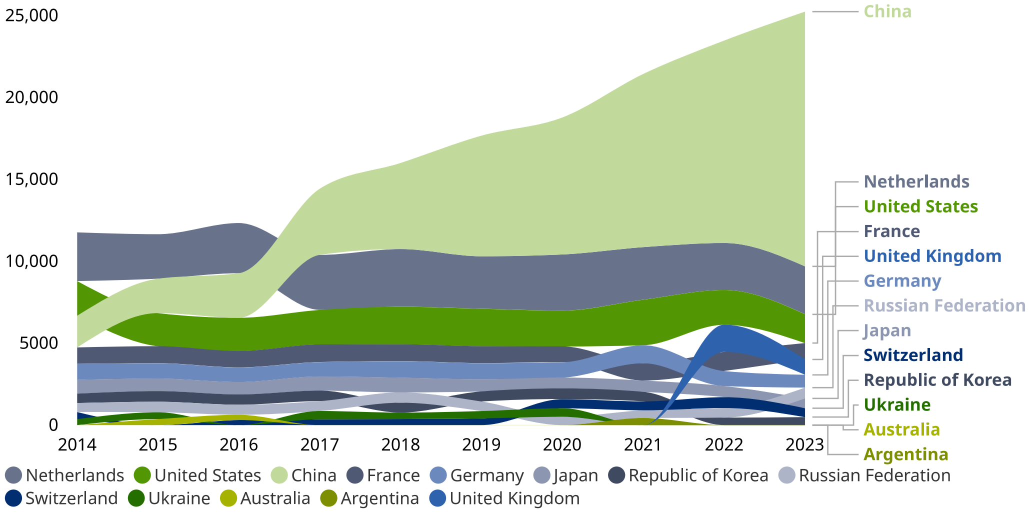
Figure 2.20 Top 10 UPOV members by number of PVP applications received (by residents and non-residents)



Source: UPOV.

The main origins of plant variety innovation, similar to patent innovation, are China, Europe, the United States, Japan, and the Republic of Korea.

Figure 2.21 Top 10 Countries of residence of applicants for PVP



Source: UPOV.

Information and training

The PLUTO Plant Variety Database[10] contains information on plant varieties from UPOV members and the Organisation for Economic Co-operation and Development (OECD), including variety denominations. The database also features a similarity search tool for preliminary check on variety denominations.

In 2024, UPOV has launched the UPOV PVP Certificate program to promote the acquisition of knowledge and recognition of expertise, as well as opportunities for continuous learning on PVP matters. The UPOV PVP Certificate provides international recognition of expertise in PVP matters. Further information is available at www.upov.int.

Emerging domains within Agrifood

Based on calculating the CAGR across various sub-domains within the Agrifood super-domain, the data reveals significant trends. In the AgriTech domain, IoT-related technologies, such as *Connectivity/sensors/smart farming, Mapping/imagery, Precision agriculture*, and *Robotics and drones* exhibit an impressive average CAGR of 8%. Similarly, in the FoodTech domain, Food chemistry and Food services also show comparable growth rates. Furthermore, other areas of AgriTech such as *Planting/harvesting/storage* and *Soil and fertilizer management* demonstrate notable CAGRs.

Drawing from previous research and expert interviews, the report has selected five highly regarded technology areas in the Agrifood super-domain for in-depth analysis, to be discussed extensively as case studies in the following chapters:

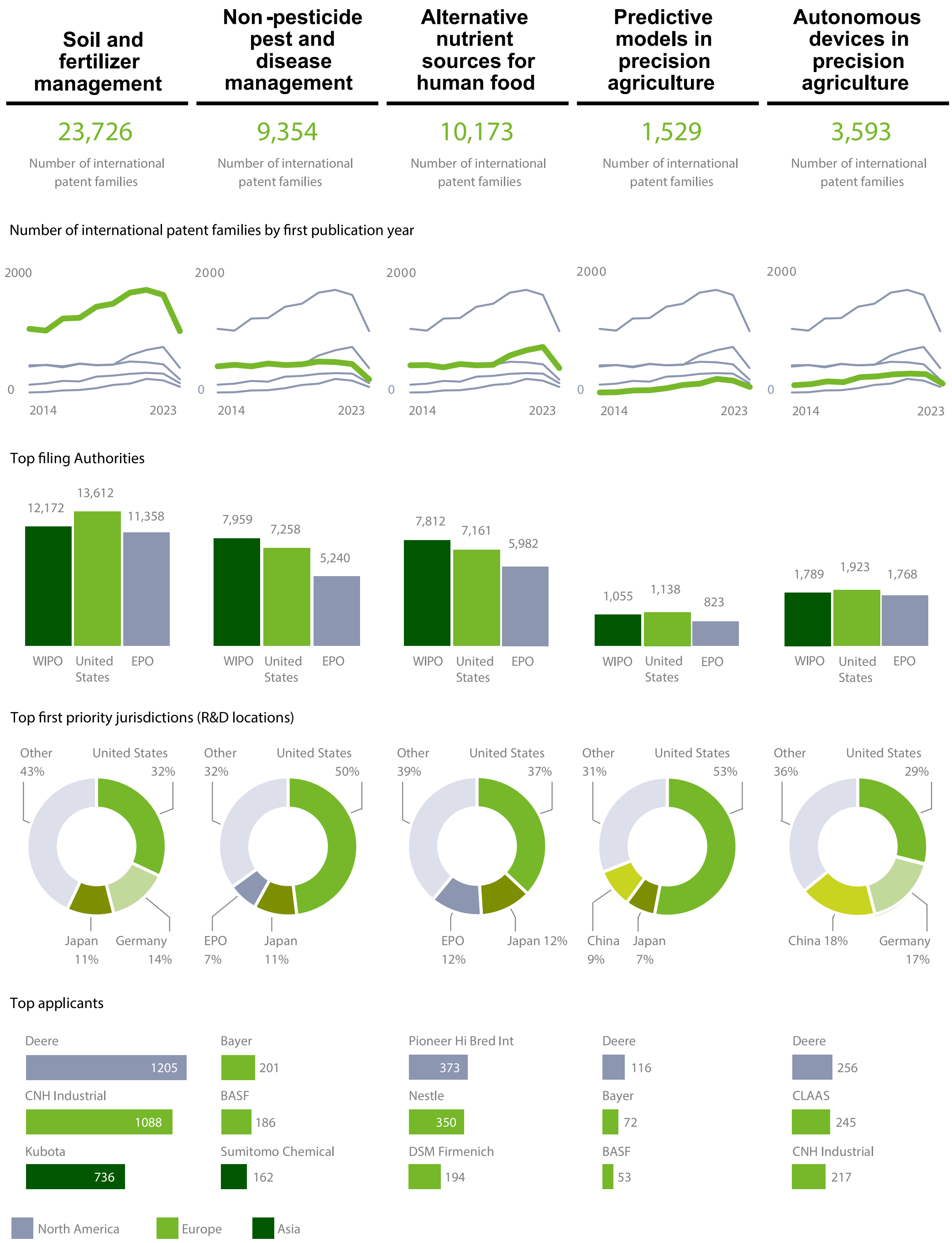
- *Soil and fertilizer management*: this includes solutions aimed at improving soil health and fertility, such as crop rotations, cover cropping, organic fertilizer usage and minimizing the use of chemical fertilizer and pesticides.
- *Non-pesticide pest and disease management*: this area focuses on alternative solutions to traditional pesticides, including the use of microbes in fertilizer formulations for biocontrol.

10 See www.upov.int/pluto/en/.

- *Alternative nutrient sources for human food*: addressing the development and promotion of alternative nutritional sources to traditional foods, such as cultured meat and plant-based proteins, to tackle challenges posed by population growth and resource constraints.
- *Predictive models in precision agriculture*: this involves the development of predictive models using AI and software to help farmers forecast market demands and optimize planting and irrigation plans, thereby enhancing agricultural production accuracy and efficiency.
- *Autonomous devices in precision agriculture*: exploring the application of autonomous machinery and robotics technology in agriculture to improve efficiency in crop planting, management and harvesting.

A snapshot of the case study technologies, highlighting patent growth, key locations and top players.

Figure 2.22 An overview of the patent landscape in five case study technological areas



Note: The data statistics are based on the number of international patent families published since 2004.
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

3 Soil and fertilizer management

Solutions aimed at improving soil health and fertility are critical in sustainable agriculture, to contribute to ecosystem biodiversity, and for water management and climate resilience reasons. This chapter summarizes the patent trends in the field of soil and fertilizer management, and discusses emerging technologies like autonomous guidance and fertilizer formulations. It also delves into the crucial role of bacteria in microbe-rich fertilizers.

Global overview

International patent activity targeting North America and Europe

The data collected from 23,736 international patent families in the *Soil and fertilizer management* sub-domain reveals a moderate CAGR of +5.6% from 2017 to 2021, as illustrated in Figure 2.22. This indicates a growing interest in the topic.

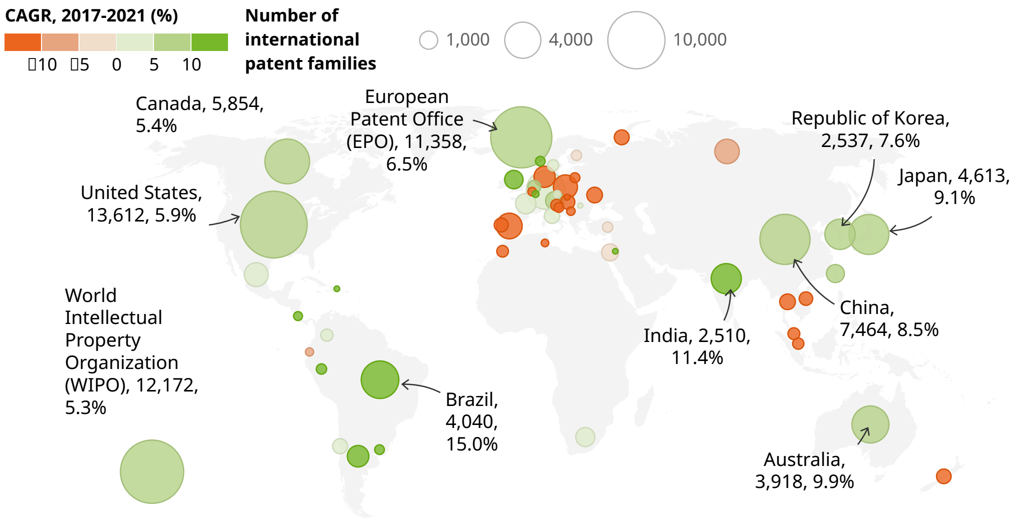
North America leads in patent filings among all continents, with the United States contributing 13,612 patents and Canada adding 5,854 patents. Europe comes in second place with a total of 11,358 patents, with Germany contributing 4,218 patents and Spain adding 1,757 patents. Asia follows closely behind, with China contributing 7,464 patents, Japan adding 4,613 patents, and India contributing 2,510 patents.

From a growth perspective, patents filed in Brazil, Argentina and India have exhibited significant growth, with CAGRs of 15.0%, 12.8%, and 11.4% from 2017 to 2021, respectively. This trend reflects the increasing interest in these countries as key markets for global AgriTech innovation. Concurrently, the CAGRs from 2017 to 2021 of international patent filings in Australia, Japan, China, the Republic of Korea, Europe (EPO), the United States and Canada also demonstrate a positive growth trajectory, with CAGRs ranging between 5% and 10% during the same period (Figure 3.1).

It is also important to mention that non-international patent families were not included in this analysis, which ultimately lowers the impact of regional jurisdictions from Asia.

USPTO, WIPO and EPO are the major filing authorities of international patent families in the Soil and fertilizer management sub-domain.

Figure 3.1 Top filing authorities in the soil and fertilizer management field



Note: The data statistics are based on the publication jurisdictions and the earliest publication year, encompassing the number of international patent families published since 2004. The CAGR is calculated using the number of international patent families published from 2017 to 2021.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Inventive regions

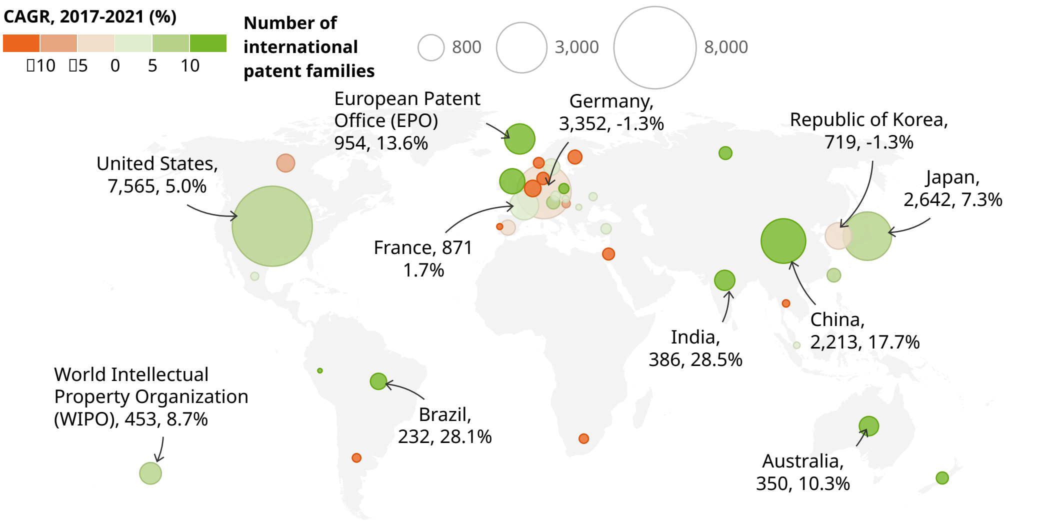
Innovation equally originates from Asia, North America and Europe

The United States leads as the primary R&D location for *Soil and fertilizer management*, with a total of 7,565 international patent families, followed by Germany with 3,352 patents, Japan with 2,642 patents, and China with 2,213 patents as shown in Figure 3.2.

Significant growth in this field is being seen in Asia, with India experiencing a CAGR of +28.5% from 2017 to 2021, and China with a CAGR of +17.7% during the same period. Latin America and the Caribbean is also seeing rapid growth, with Brazil showing a CAGR of +28.1% from 2017 to 2021. Dynamics of international patent filing in Europe and North America are generally steady, with an average CAGR for 2017 to 2021 for top 5 jurisdictions in Europe of +2.7%, while the average CAGR for 2017 to 2021 for both the United States and Canada is +4.7%.

The United States leads in Soil and fertilizer management R&D, with significant growth in Asia and Latin America and the Caribbean.

Figure 3.2 Top first priority jurisdictions in the Soil and fertilizer management field



Note: The data statistics are based on the first priority jurisdictions and the earliest publication year, encompassing the number of international patent families published since 2004. The CAGR is calculated using the number of international patent families published from 2017 to 2021.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Regional innovative strategies for Soil and fertilizer management

North America

Innovation in the United States is supported by the National Aeronautics and Space Administration (NASA), which collaborates with the U.S. Department of Agriculture (USDA) to share and apply space-based measurements of soil moisture to strengthen predictions of agricultural and climate trends and support research on the carbon cycle. The United States is also supporting, with investments of US$330 million, 85 locally driven, public–private partnerships to address climate change, improve the nation's water quality, combat drought, enhance soil health, support wildlife habitat and protect agricultural viability.

Europe

Europe supports partner locations to reduce their dependency on imported mineral fertilizers by investing in efficiency of use, alternative green and organic fertilizers, and sustainable agricultural practices and soil fertility management (e.g. agro-ecology), as highlighted in the Communication on fertilizers[1] published on November 9, 2022. Moreover, the Soil Strategy for 2030 and the announcement to propose a Soil Health Law aims to tackle the problem of continuing and aggravating soil degradation in the Europe and presents healthy soil as an important solution for biodiversity and climate crises as well as to prevent fresh- and seawater degradation, but also for other societal challenges such as food security and safety.

The new strategy sets the vision that by 2050 all soils should be healthy and resilient in Europe, which will require decisive changes.

Additional regional actions in the United Kingdom can be cited[2]: in order to meet the net zero carbon emissions target by 2050 and enhance soil health, there is a need to recycle nutrients more in the future. The United Kingdom is modernizing its domestic policy for fertilizer

1 European Commission. Food security: availability and affordability of fertilisers. (https://ec.europa.eu/commission/presscorner/detail/en/ip_22_6564).
2 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).

regulation which will be informed by expert analysis of existing policy, alongside up-to-date technical and scientific evidence on fertilizers and nutrient management. It is engaging with sector sounding boards, including industry representatives and other key stakeholders, to ensure its recommendations have practical merit.

Asia

In Asia, Malaysia promotes the adoption of technology, R&D and creative methods to help food producers better manage farm activities, minimize reliance on manual labor, promote natural resource conservation and adapt to climate change effects. These elements will improve the plant and animal stock, as well as the soil. The Republic of Korea will develop technologies to prevent the erosion of highland field topsoil and expand sewage treatment facilities to protect water designated for aquaculture.[3]

Africa

In Africa a large number of initiatives promotes sustainable soil management, as well as water and biodiversity management practices.[4] Cameroon, the Democratic Republic of the Congo, and Sudan adopt practices to restore, protect and manage natural resources in a sustainable manner: soil conservation and appropriate water harvesting.

Namibia, as a dry location, promotes regenerative agricultural practices and microorganisms build-up to ensure soil fertility, moisture retention and carbon storing, to reverse biodiversity loss, halt bush encroachment, improve pastures and encourage restoration of the ecosystem to unlock ecosystem benefits. For a dry climate, it is commendable that some beneficial microbes have been identified in opening prospects for inoculant technology or biofertilizers which can substitute synthetic nitrogen-based fertilizers. The use of nature-based solutions which are environmentally friendly can greatly support organic farming and contribute to nutritious, safe foods. Due to high variability, these solutions/strategies need to be tailored per agro-ecology and consider environmental variations (soils, water, temperature) for adaptation.[5]

In Algeria, initiatives have been carried out by the Trait d'Union association with a panel of farmers, and technical and research institutes, around direct seeding, in order to maintain soil moisture, sometimes avoid erosion, sequester carbon and thus limit GHG emissions.[6]

Zambia promotes the use of efficient agroforestry and aquaculture techniques, as well as sustainable soil management, crop rotation, integrated fish farming and diversification among small-scale farmers.[7]

Zimbabwe expands the Government of Zimbabwe-led policy action to support adoption of climate-smart and/or conservation agriculture to safeguard food security and nutrition of farmers. Conservation agriculture protects the soil and the environment through ensuring sustainable soil and water management and irrigation, in the different agro-ecological zones.[8]

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3 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).
4 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).
5 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).
6 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).
7 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).
8 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).

Top players

Worldwide manufacturers of agricultural machinery leading the domain

Considering the top 50 players in *Soil and fertilizer management* , industrial actors largely dominate the segment by 97% compared to academic ones. The majority of top players in the industry are primarily from Germany, making up 33% of the total, followed closely by Japan at 23%. A more focused examination of the top 10 players shows that these companies collectively hold ownership of 18% of the international patent families. These top players consist of manufacturers of agricultural machinery such as Deere, CNH Industrial and Kubota, as well as German chemical companies such as BASF and Bayer (Figure 3.3).

Despite a low number of companies from the United States in this top actor (13%), Deere emerges as the main the contributor to patents on soil working. It holds patents covering agricultural machines, including tractors, seeding machines, sprayers and autonomous steering solutions. Deere exhibits a strong and diversified portfolio with worldwide extensions. AGCO and Caterpillar are the other United States-based key players developing machines for soil working, sowing and planting.

CNH Industrial is the only actor from the United Kingdom with this ranking. Formerly Fiat industrial, CNH covers agricultural machines for tillage, seeding, planting and fertilizer distributors, as well as sensors for soil monitoring. Despite a high number of patents with worldwide extensions in diversified aeras, CNH Industrial's portfolio is less impactful with a lower number of non-self forward citations compared to Deere.

Kubota is part of a list of Japanese manufacturers of engines and agricultural machines covering the field, including Yanmar, Honda Motor, Iseki and Toyota Motor. They all focus their development on a large set of solutions dedicated to the automated steering of tractors and automated guidance using satellites. If Kubota, Yanmar and Iseki mostly innovates into seedling and transplanting machines, Honda shows a large patent portfolio dedicated to mowers, and Toyota Motor to electric power-driven machines. Asian top companies majorly protect their innovations within Asian jurisdictions (China, Japan, India, the Republic of Korea), the United States and Europe, with additional few extensions in national phases.

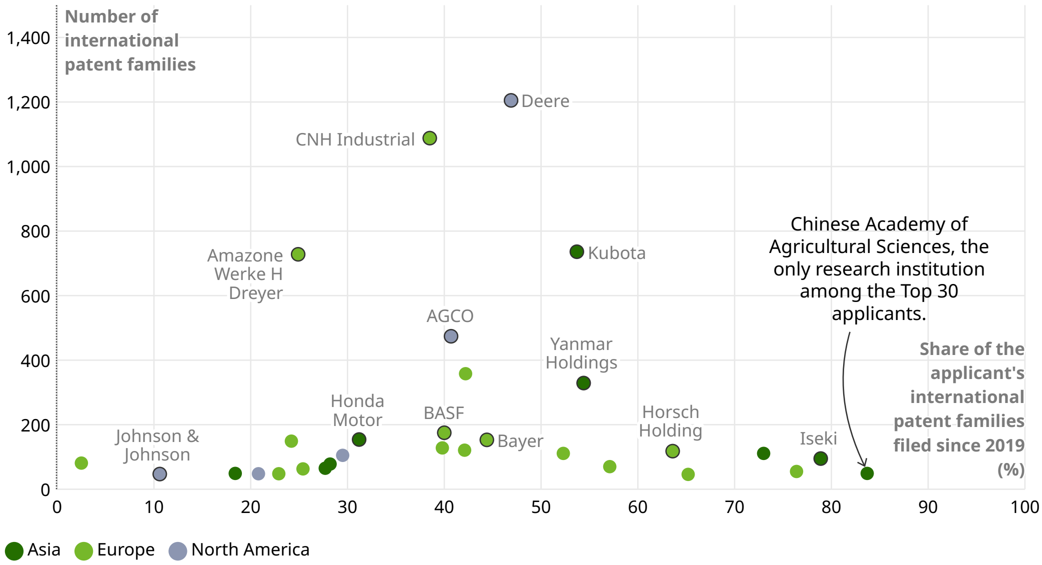
Amazonen-Werke H Dreyer is a manufacturer of agricultural machines from Germany. This company has huge expertise in seeding and fertilizing apparatus, notably liquid sprayers with a diversified portfolio on these areas. Major German companies in this field have already developed technologies for autonomous steering of agricultural machines. One of them, Horsch Holding, shares the same profile to a lesser extent. Other German top companies, (including CLAAS, Robert Bosch Stiftung, Lemken, Horsch, Pottinger, Rauch Landmaschinenfabrik and Zeppelin Stiftung) show an extensive portfolio dedicated to lifting solutions as well as seeding and planting. German top companies largely favor United States and Europe protection compared to Asia (China, Japan, India, the Republic of Korea).

BASF and Bayer are two German chemical and agrochemical companies. BASF shows an extensive expertise in fertilizer and additive formulation supporting crop growth. Together with Bayer, BASF is also a leader in biocides (pesticides, insecticides, fungicides), crop preservatives and plant growth regulators.

Within the non-industrial players, only Chinese Academy of Agriculture Sciences emerges as a unique leader, with patents dedicated to the formulation of fertilizers, some of them containing agricultural microorganisms enhancing nitrogen fixation, and distribution devices.

Top players are agricultural machinery manufacturers such as Deere, CNH Industrial and Kubota, as well as chemical companies like BASF and Bayer.

Figure 3.3 Top applicants in the Soil and fertilizer management field



Note: The data statistics are based on the number of international patent families published since 2004.
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Emerging technologies: autonomous guidance and fertilizer formulations

Autonomous guidance and fertilizer formulations leading technology trends in Soil and fertilizer management, driven by major agricultural and chemical companies

Global ranking of International Patent Classification (IPC) subclasses was achieved regarding the total number of international patent families. The variation in number of documents over 2017 to 2021 was computed to identify emerging technologies (Figure 3.4).

Innovations in *Soil and fertilizer management* can be classified in two main categories encompassing high volumes of international patent families:

- The first one is related to agriculture in general, including *soil working* (A01B), *Horticulture* (A01G), *Planting* (A01C), *harvesting* (A01D), and *Biocides* (A01N).
- The second domain highly represented by innovation volume is the one related to fertilizers, including *mixtures* (C05G), *organic* (C05F) and *inorganic* (C05D) ones.

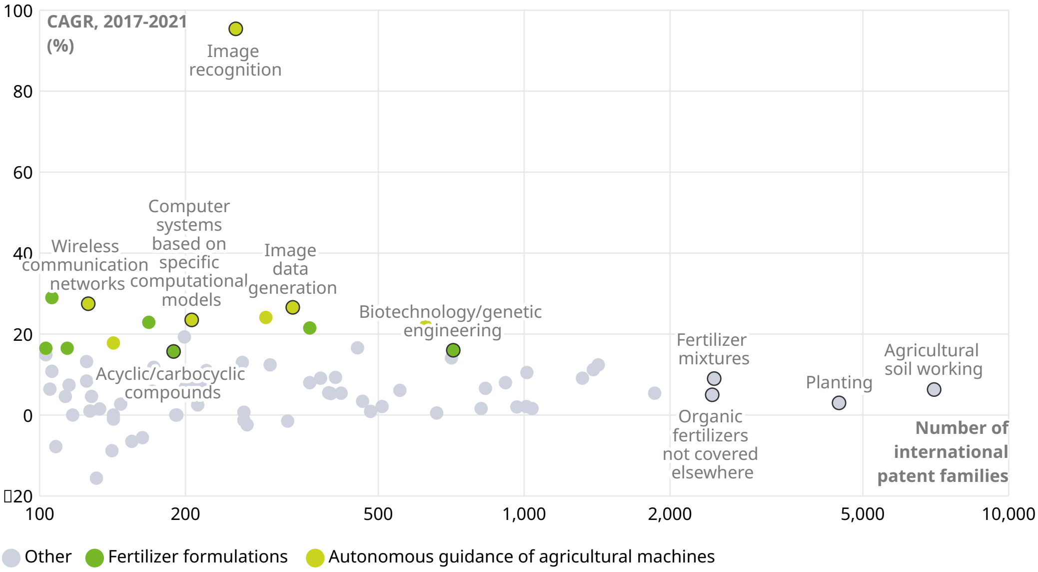
According to the selection criteria described above, 16 fast-growing IPC subclasses (CAGR2017–2021 > 15%), corresponding to high tech applications, were chosen for in-depth analysis.
For statistical relevancy, we choose to only consider subclasses encompassing up to 100 international patent families.

Two main trends can be extracted from this list of IPC subclasses:

- *Autonomous guidance of agricultural machines*, using *image recognition technics* (G06V), *image processing* (G01B, G05B, G06N, G06T) and *information communication technologies* (G06Q, H04W)
- *Fertilizer formulations* (C01C, C04B, C07C, C08G), comprising *microorganisms* (C12N, C12R).

Innovations in Soil and fertilizer management focus on two main categories: fertilizer formulations and autonomous guidance of agricultural machines.

Figure 3.4 Comparing the number of international patent families and the (CAGR) of each IPC subclasses in the Soil and fertilizer management field



Note: The data statistics are based on the number of international patent families published since 2004. The CAGR is calculated using the number of international patent families published from 2017 to 2021.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

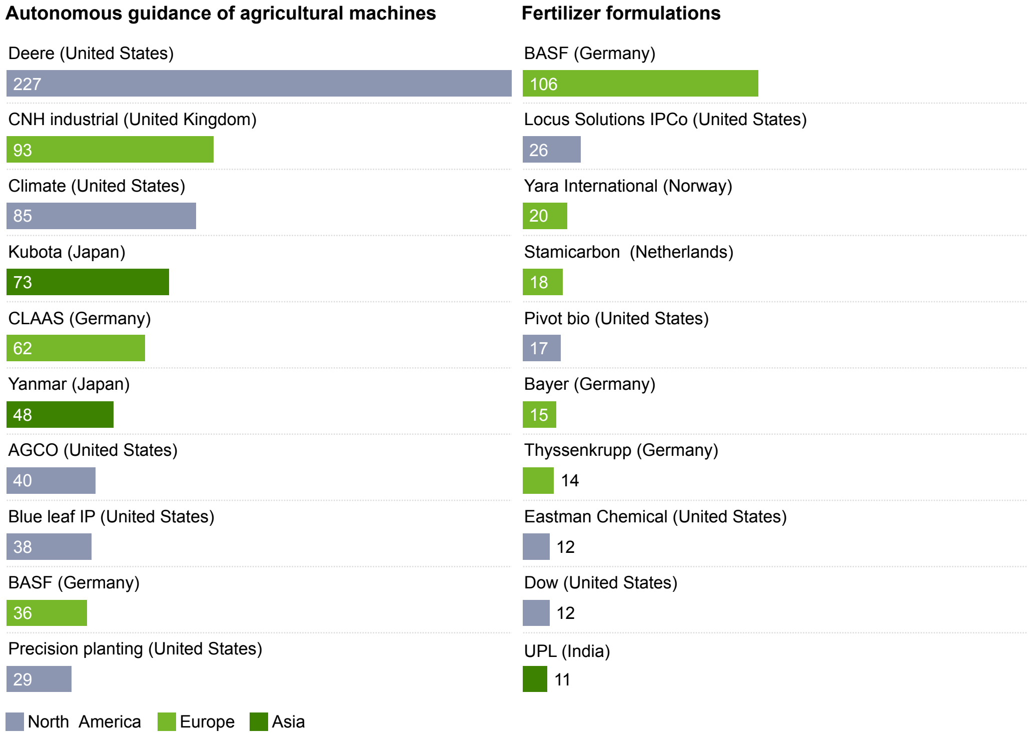
Top players show a clear segregation regarding groups of IPC subclasses (Figure 3.5):

Deere, CNH Industrial, Climate, Kubota, AGCO, CLAAS, Yanmar Holdings are all well-known agricultural machinery and equipment manufacturers, and they mostly filed patents related to *autonomous guidance of agricultural machines*.

BASF, Locus Solutions IPCo and Yara International are companies in the chemical and fertilizer sectors. They are key players having a high impact on *fertilizer formulation*.

Deere, CNH Industrial and Climate are the top applicants in autonomous guidance of agricultural machines field. BASF, Locus Solutions IPCo and Yara International are the top applicants in fertilizer formulation field.

Figure 3.5 Top applicants in fast-growing areas of the Soil and fertilizer management field



Note: The data statistics are based on the number of international patent families published since 2004.
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Technology at a glance: weed control module and device and method for laser-based weed control

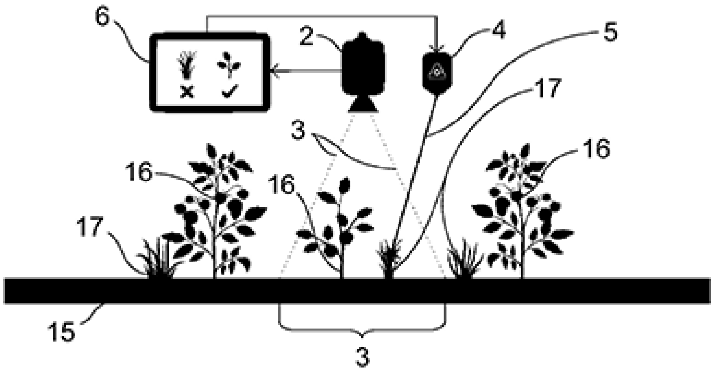
Publication Number: DE102023103252

Applicant: Escarda Technologies GmbH

Application Date: 10.02.2023

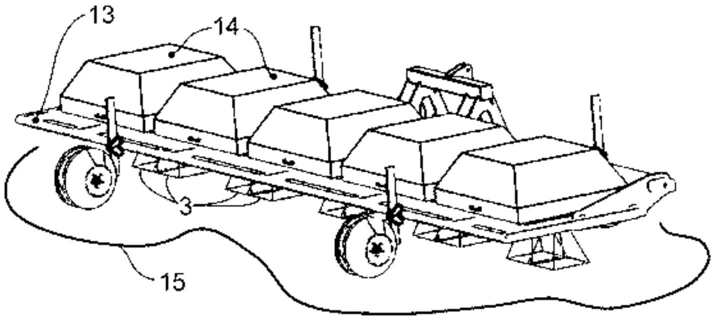
This patent related to a laser-based weed control module with image recognition technology. A laser-based weed control module for agricultural areas uses image recognition, laser technology and AI to selectively target and eliminate weed plants while preserving useful plants. The technology offers an environmentally friendly and chemical-free approach to weed control, enhancing efficiency and effectiveness. The technology provides a simple, energy-efficient and environmentally friendly weed control solution.

Figure 3.6 Laser-based weeding device



Source: DE102023103252.

Figure 3.7 Agricultural vehicle trailer comprising the Laser-based weeding device



Source: DE102023103252.

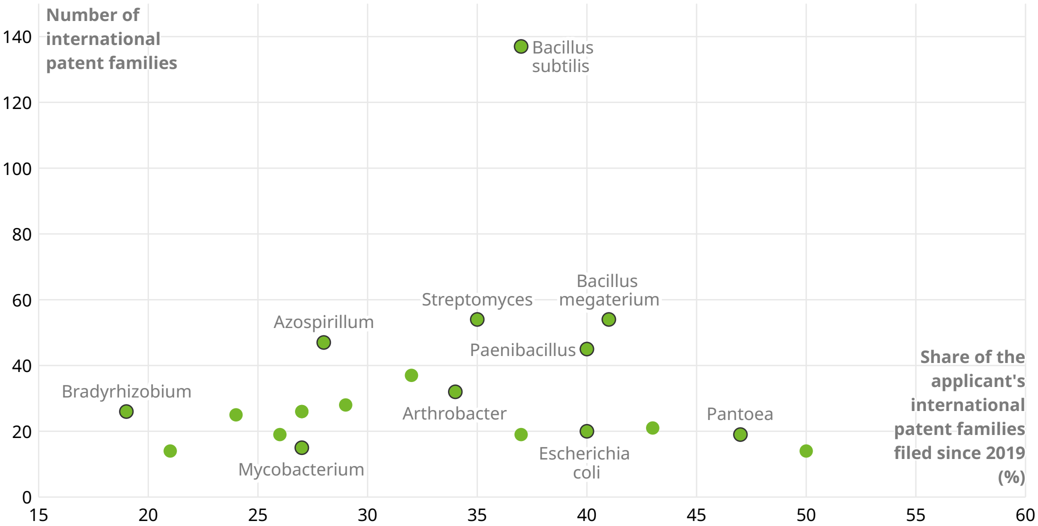
Deep dive: bacteria

Bacteria is the vital component of microorganism-enriched fertilizers

Semantic analysis of the top redundant concepts in the Orbit database has isolated "Bacteria" as a notion of interest. Thanks to their ability to convert nitrogen gas to ammonia, bacteria can not only provide nutrients that plants need, but also help regenerate soil to ultimately enhance yield and quality of agricultural products (Figure 3.8).

Bacillus subtilis has the most international patent families, while interest in R&D for Rhodopseudomonas, Pantoea, Pseudomonas aeruginosa, and Bacillus megaterium has grown in recent years.

Figure 3.8 Semantic analysis of microorganism-related concepts in the fertilizer formulations field



Note: The data statistics are based on the number of international patent families published since 2004.
Source: WIPO, based on patent data from Orbit, March 2024.

Notably *Bacillus subtilis* is the most popular microbial fertilizer in market, boosting plant growth in a sustainable and environmentally friendly manner: (1) It enhances the uptake of essential nutrients by plants, for example by solubilizing phosphorus; (2) It also produces antimicrobial compounds that can help suppress soil-borne pathogens and reduce the risk of plant diseases; (3) It produces enzymes that help break down organic matter in the soil, resulting in improved soil structure and increased water retention, leading for better root development. Currently, there are 137 international patent families involving *Bacillus subtilis*. This number far exceeds that of other types of bacteria.

The bacteria belonging to the second tier in terms of the number of related patents include Bacillus megaterium (54 international patent families), Streptomyces (54 international patent families), *Azospirillum* (47 international patent families), and *Paenibacillus* (45 international patent families).

- *Bacillus megaterium*, a beneficial soil bacterium, has the remarkable ability to fix atmospheric nitrogen, solubilize phosphorus and produce plant growth-promoting hormones. This microbial fertilizer can significantly improve soil fertility, leading to an increase in crop yields and enhanced plant health. With its multiple benefits for soil and plant health, *Bacillus megaterium* stands out as a valuable tool for sustainable agriculture practices.
- *Streptomyces* is renowned for its capacity to synthesize a diverse array of bioactive compounds with beneficial effects on plants. These compounds play a crucial role in promoting plant growth and bolstering defense mechanisms against harmful pathogens. As a microbial fertilizer, *Streptomyces* has been shown to significantly enhance nutrient absorption, enhance soil quality by improving its structure and boost plants' resistance to various diseases, making it a valuable tool for sustainable agriculture.
- *Azospirillum*, a nitrogen-fixing bacterium, has the capability to improve the growth of nitrogen-demanding crops. Serving as a microbial fertilizer, *Azospirillum* has been shown to boost nitrogen availability in the soil, enhance plant nutrient absorption and stimulate root growth. These benefits make *Azospirillum* a valuable tool for farmers looking to optimize crop production and improve overall plant health.
- *Paenibacillus* is a versatile soil bacterium that can promote plant growth, suppress plant pathogens and improve soil fertility. As a microbial fertilizer, *Paenibacillus* can increase nutrient availability, enhance plant resilience and boost crop productivity.

In addition to the above-named bacteria:

- *Pseudomonas fluorescens* is a beneficial soil bacterium that can suppress plant diseases, degrade organic pollutants and improve nutrient cycling. *Pseudomonas fluorescens* can enhance plant health, increase soil fertility and promote sustainable agriculture practices.
- *Arthrobacter*, a soil bacterium, has the capability to break down organic matter, enhance soil structure and improve nutrient cycling. Serving as a microbial fertilizer, *Arthrobacter* has been shown to boost nutrient availability while also promoting soil health and supporting plant growth.
- *Pseudomonas putida* is a versatile soil bacterium that can degrade toxic compounds, promote plant growth and enhance nutrient cycling. *Pseudomonas putida* can improve soil quality, increase crop yields and support sustainable agriculture practices.
- *Bradyrhizobium*, a nitrogen-fixing bacterium, establishes symbiotic relationships with leguminous plants, ultimately benefiting agriculture in a sustainable way.
- *Bacillus cereus* is a soil bacterium that can promote plant growth, suppress plant pathogens and improve soil fertility. As a microbial fertilizer, *Bacillus cereus* can enhance nutrient uptake, increase resistance to diseases and support sustainable agriculture practices.

Technology at a glance: microbial products that fixate carbon and other plant nutrients in the soil

Andes AG, Inc. leverages innovative microbial technology, employing genetically engineered microorganisms to symbiotically interact with plants to sequester carbon and other nutrients in the soil, thereby improving agricultural productivity and reducing greenhouse gas emissions. These microorganisms effectively remove CO_2 from the atmosphere and convert it into soil minerals. The carefully designed and selected microorganisms grow around crop seeds (such as corn and wheat), working symbiotically with plant roots to convert CO_2 into bicarbonate and carbonate. By applying these microorganisms to soil along with seeds, Andes' technology transforms agricultural fields into carbon sinks while supporting food production. The accumulation of minerals in the soil also offers several benefits, including improved drainage, increased nutrient content, reduced plant diseases and stabilized soil organic matter.[9]

The related patent WO2022/087289 describes methods and compositions utilizing microorganisms associated with plant seeds to produce bicarbonate, carbonate or other minerals. This patent provides detailed methods for introducing microorganisms into plant seeds, selecting specific microorganisms to promote CO_2 fixation and mineralization. These microorganisms can be located between the coating and cell layers of plant seeds, playing a role during seed germination and plant growth. The patent also emphasizes the stability of these microorganisms under various environmental conditions and their compatibility with traditional agricultural distribution chains, making them highly efficient and practical for real-world applications.

Another patent, US20230322641, involves the use of the Microprime™ seed treatment method to introduce microorganisms into plant seeds. This method involves contacting seeds with a solution containing specific bacteria and incubating them under appropriate conditions to successfully incorporate the bacteria into the seeds, particularly between the seed coat and the embryo. These microorganisms effectively sequester CO_2 during plant growth, converting it into beneficial carbonates and minerals, thereby enhancing soil carbon storage capacity.

Through these patents and technologies, Andes not only provides environmentally friendly and sustainable solutions for agricultural production but also optimizes CO_2 fixation and conversion, reducing reliance on fossil fuels and greenhouse gas emissions. These innovations significantly improve soil quality, promote healthy plant growth and offer farmers efficient and eco-friendly agricultural techniques.

9 Green Technology Book: Solutions for climate change mitigation, WIPO (www.wipo.int/green-technology-book-mitigation/en/).

4 Non-pesticide pest and disease management

Alternative solutions to traditional pesticides prevent soil and water contamination and helps manage pest resistance. This chapter spotlights emerging technologies, such as the potential use of microbes and their derivatives as substitutes for traditional pesticides and advancements in formulation technology. It also explores the Non-pesticide pest and disease management strategies, analyzing patents to identify the most frequently mentioned pests to be prevented and the cultures intended to be protected.

Global overview

Sustained patent filing activity in the last decade

Non-pesticide pest and disease management encompasses a range of innovations designed to control crop pests without relying on chemical pesticides. The approaches vary a lot and include:

- *Living organisms*: various species of animals and microorganisms used as natural enemies, predators or infectious agents of agricultural pest species
- *Compositions*: these can be chemical or natural substances that act as repellents to deter pests, attractants to lure them into traps, or even bio-natural pesticides derived from essential oils, plant extracts or microorganisms
- *Devices*: traps, sprayers and dispensers used in conjunction with other biocontrol methods
- *Genetic modification*: production of transgenic plants resistant to specific pests.

Upon analyzing 9,354 international patent families, it was found that there is a flat growth trend in the technological field, with a CAGR of +1.4% between the years 2017 and 2021 (Figure 2.22). This indicates that the field may be mature, with no significant emergence of disruptive technology.

WIPO has processed the highest number of international patent families in this field, totaling 7,959, indicating that many applicants seeking patents outside their home countries opt for the PCT route. This is closely followed by the United States with 7,258 international patent families. In third position, EPO filing (Europe) accounts for a total of 5,240 international patent families (Figure 4.1).

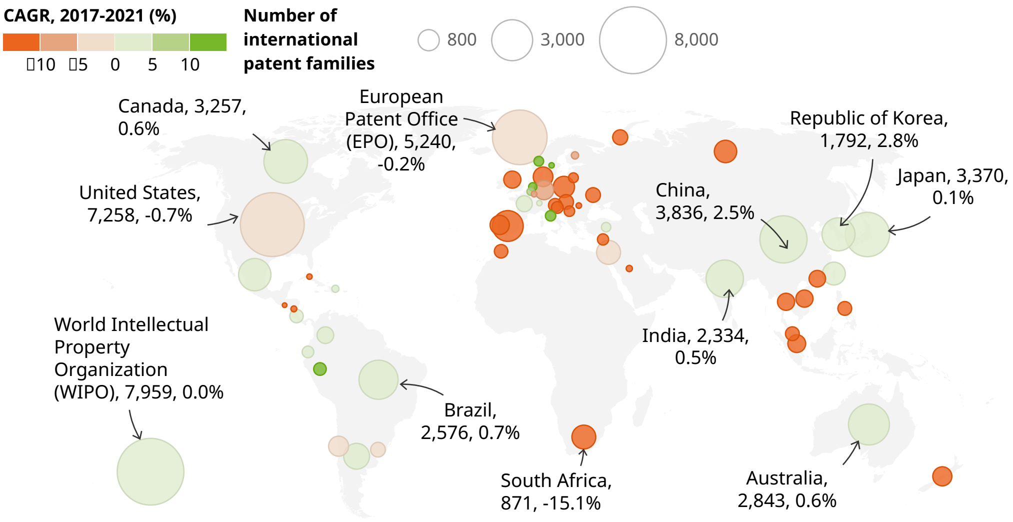
Asia is not far behind, with China making a significant contribution of 3,836 international patent families, Japan adding 3,370 international patent families, India contributing 2,334 international patent families, and the Republic of Korea with 1,792 international patent families. Oceania and Latin America and Caribbean are also represented, respectively with Australia having 2,843 international patent families, and Brazil with 2,576 international patent families.

It is also important to highlight that this analysis does not include non-international patent families, which may have an impact on the overall influence of Asian jurisdictions in the patent filing landscape.

Regarding the growth rate of international patent families, China and the Republic of Korea show an upward trend, with a CAGR of 2.5% and 2.8% from 2017 to 2021 respectively. The number of patents filed in Canada, India, Australia, Brazil, and those processed by WIPO has remained relatively stable.

Protection for Non-pesticide pest and disease management is global, led by WIPO (PCT), the United States, Europe, and Asian jurisdictions.

Figure 4.1 Top filing authorities in the Non-pesticide pest and disease management field



Note: The data statistics are based on the publication jurisdictions and the earliest publication year, encompassing the number of international patent families published since 2004. The CAGR is calculated using the number of international patent families published from 2017 to 2021.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Inventive regions

Pesticide replacement as a major concern worldwide

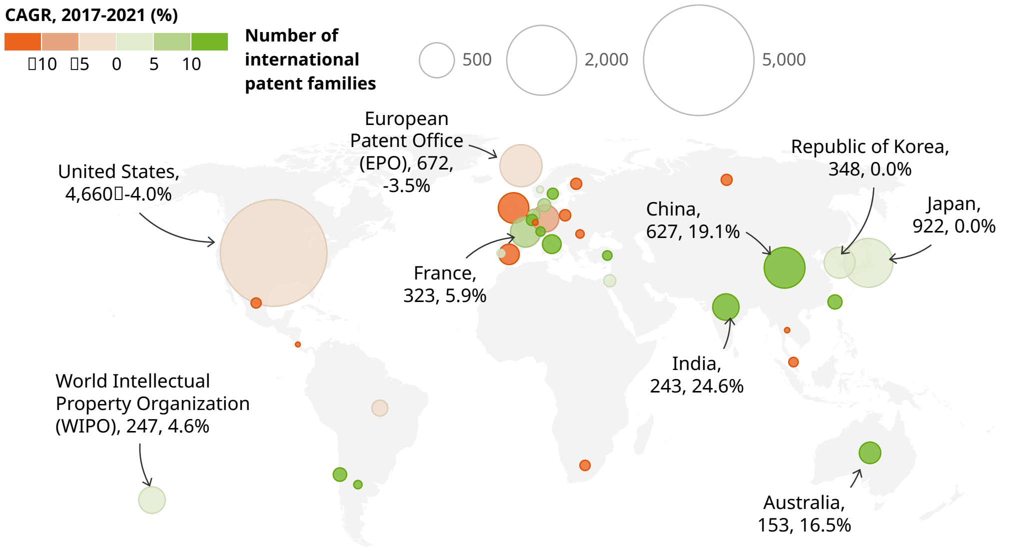
According to Figure 4.2, North America is the leading location for R&D activities, with the United States accounting for over 99% of the total. Despite this dominance, there are indications of a possible decline in R&D activity in the region. The CAGR for R&D filings from 2017 to 2021 is negative, standing at -4%. This suggests a potential slowdown in innovation and research efforts in North America in the coming years.

In recent years, Asia has emerged as a key player in the field of R&D. This is evident from the substantial number of first priority filings in the region, totaling 2,278. Furthermore, the CAGR for patent filings in Asia between 2017 and 2021 was recorded at +5.6%. China and India are on an upward trajectory, experiencing strong CAGRs of +19.1% and +24.6%, respectively. On the other hand, Japan and the Republic of Korea, while still being large sources of patents in the region, with 922 and 348 international patent family filings respectively, have maintained stable patent application volumes with a CAGR from 2017 to 2021 of 0%.

The first-filing dynamic in Europe reveals a concerning trend, with an overall flat CAGR of -0.8%. This trend seems to be driven by a decrease in filings from all major European jurisdictions except France, which has seen a growth of 5.9% in first filings during the 2017–2021 period.

The United States is the primary location for R&D, but a negative CAGR in international patent families from 2017 to 2021 indicates a potential decline in innovation.

Figure 4.2 Top first priority jurisdictions in the Non-pesticide pest and disease management field



Note: The data statistics are based on the first priority jurisdictions and the earliest publication year, encompassing the number of international patent families published since 2004. The CAGR is calculated using the number of international patent families published from 2017 to 2021.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Regional innovative strategies for Non-pesticide pest and disease management

Asia

Several regional policies support the growth trend of the patents related to non-pesticide pest and disease management in Asia.[1]

- China practices green development and has formulated and implemented the National Sustainable Agricultural Development Plan (2015–2030), launched initiatives to reduce the application of chemical fertilizers and pesticides for efficiency gains, and actively extended efficient agricultural technologies that save water, fertilizers or pesticides.
- Japan supports sustainability of agriculture, forestry and fisheries by reducing the environmental load caused by the use of chemical pesticides and chemical fertilizers through the circulating use of organic resources and disseminating smart agriculture, forestry and fisheries, customizing them to each region.
- The Republic of Korea will boost measures to control pests and diseases based on inspections to find newly emerging pest species as a result of climate change.

Europe

In the European Union, the Biodiversity Strategy aims to protect nature and reverse the degradation of ecosystems.[2] This strategy aims to build societies' resilience to future threats (forest fires, food insecurity, climate change, disease outbreaks) and sets global targets to protect and restore biodiversity in Europe across natural and managed ecosystems. The Commission adopted the legal proposals on Nature Restoration Law and Sustainable Use of Pesticides. The 15th Conference of the Parties to the Convention on Biological Diversity (CBD

1 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).
2 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).

COP15), to which Europe and all its member states are party, adopted the Kunming-Montreal Global Biodiversity Framework (GBF). [3]The associated proposal for a Regulation on Sustainable Use of Pesticides has a target of reducing by 50% the use and the risk of chemical pesticides by 2030 as well as the new rules on environmentally friendly pest control. This aims to reduce the environmental footprint of Europe's food system, protect the health and well-being of citizens and agricultural workers, and help mitigate the economic losses that are already being incurred due to declining soil health and pesticide-induced pollinator loss.

Other regional policies provide additional support.

- The French Ecophyto II+ plan aims to accelerate the withdrawal of substances of greatest concern[4]; promote the recognition and dissemination of biocontrol products and natural preparations of little concern; strengthen the prevention of public exposure to pesticides and their impact on the environment and biodiversity; support research, in particular on alternative solutions; support farmers in the transition with a set of measures including exchanges between farmers.
- Spain promotes measures to ensure sustainable food production: these measures respond to the urgent need to reduce reliance on pesticides and antimicrobials, reduce over-fertilization, increase organic farming, improve animal welfare and reverse biodiversity loss. It includes objectives in the 2030 horizon (also included in the Europe Biodiversity Strategy 2030) to promote actions that aim to reduce the use and risk of synthetic chemical pesticides, to a greater extent high-risk pesticides; reduce the loss of nutrients (especially phosphorus and nitrogen) and the use of fertilizers; reduce sales of antimicrobials for farm animals and in aquaculture; increase the agrarian surface of ecological agriculture.
- The United Kingdom government is helping to fund work to research, develop and promote means to reduce reliance on chemical pesticides and maximize the use of lower risk methods, including improving indicators, increasing the use of nature-based, low-toxicity solutions and precision technologies, with the potential to enhance biodiversity.[5]

Top players

German and the United States agrochemicals at the forefront of the field

The *Non-pesticide pest and disease management* field is dominated by industrial actors, with 12 out of the top 20 patent applicants falling into this category (Figure 4.3). These include established chemical and agrochemical giants like BASF and Bayer, which hold the top spots. Notably, 4 out of the 16 private entities are United States-based companies, while the remaining industrial players come primarily from Japan (Sumitomo Chemical, Shin-Etsu Chemical and Earth).

BASF and Bayer boast diverse biocontrol technologies. Their portfolios encompass devices for insect control, such as bait stations and traps, biocompositions targeting specific pests and chemical formulations working as allelochemicals.

Asian players in the field are largely established chemical companies, including Sinochem from China and Sumitomo Chemical and Shin-Etsu Chemical from Japan. Shin-Etsu focuses on innovative pheromone-based pest control solutions, while Sumitomo's patent filings highlight methods that utilize essential oils and devices for their dissemination, such as heat evaporation units.

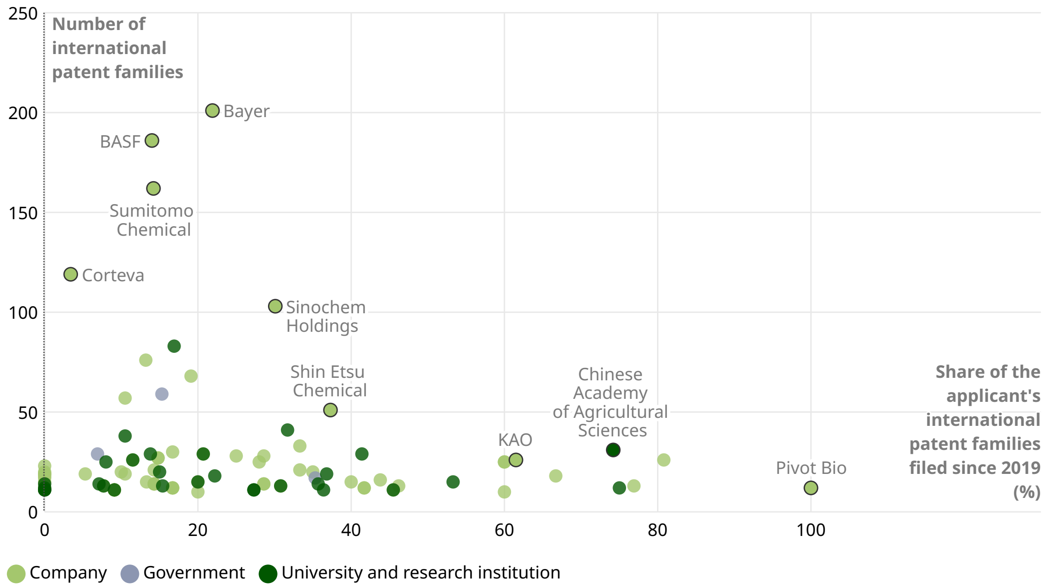
3 Convention on Biological Diversity (https://www.cbd.int/gbf).
4 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).
5 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).

Seoul Semiconductor, through its subsidiary Seoul Viosys, primarily focuses on protecting innovations related to insect traps using ultraviolet lights. Companies from the United States leading the field exhibit more diverse approaches. FMC Corporation, a prominent chemical company specializing in agrochemical technologies and pest control products, holds patents for methods of producing insect pheromones and bacterial strain compositions that benefit plant growth and combat plant diseases. AgriTech companies from the United States, such as Pioneer Hi-Bred and Corteva, developed diverse approaches centering on chemical compounds, peptides, and DNA-based methods/compositions for pest control.

Academic institutions from the United States, France and China also make their presence felt among the top players. Notably, France's CNRS and INRA have developed technologies across various biocontrol compositions. Their inventions include repellents, attractants, pesticide properties derived from plant extracts and protein-based compositions that target pheromone receptors.

The Non-pesticide pest and disease management field is dominated by industrial actors, including BASF, Bayer, and other companies from the United States, Japan and France.

Figure 4.3 Top applicants in the Non-pesticide pest and disease management field



Note: The data statistics are based on the number of international patent families published since 2004.
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Emerging technologies: microorganisms

Using microorganisms and their derivatives might be slowly gaining ground as an alternative to conventional pesticides

The number of international patent families in IPC subclasses and the variation in the number of international patents in these IPC subclasses during the period from 2017 to 2021 have been analyzed to identify emerging technologies (Figure 4.4).

The top of the most represented IPC classification subclasses, A01N, A01P and A61K generally point to the application domains of technical solutions (biocides, pest repellents or attractants, anti-infectives, antiparasitic agents) not allowing a conclusion as to their nature/origin without further analysis. Meanwhile, in the top 10 of the most represented subclasses, there are subclasses related to microorganisms: C12N, C12R; to trapping systems: A01M; and to new plant variety creation including genetic modification: A01H.

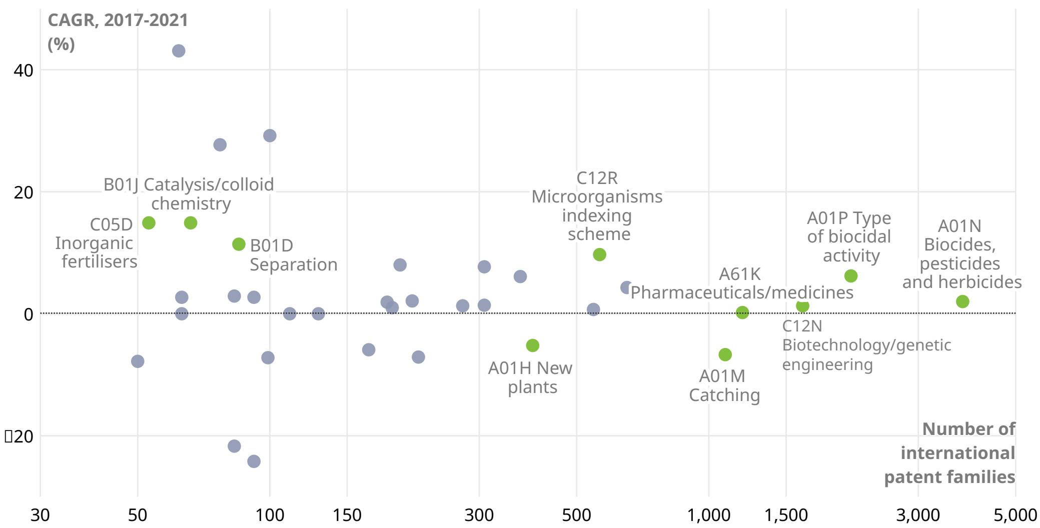
To identify growing IPC subclasses, the CAGR in the period from 2017 to 2021 was calculated for each of them, highlighting rapidly expanding areas of interest. The analysis revealed some fast growth IPC subclasses related to chemical separation (B01D), physical or chemical treatment

(B01J), and inorganic fertilizers (C05D) comprising correspondingly patents on extraction of active compounds with pesticidal properties from microorganisms (WO2013/110258, WO2014/063070), encapsulation of active compounds (WO2022/182793, WO2022/123596), and co-formulation of fertilizers with biocontrol agents, most often for seed treatment (US20230048051, WO2020/245586).

While filing patents in the field of trapping systems is declining, with a negative CAGR for the period from 2017 to 2021, one IPC subclass, from the top 10 most represented, namely C12R, showed a CAGR of nearly 10% or higher. This subclass focuses on categories related to indexing microorganisms. It includes patents related to plant microorganism pathogens and biological methods aimed at enhancing plant health and preventing diseases caused by pathogenic microorganisms. Additionally, this subclass covers methods that utilize microorganisms to promote plant growth or combat pest pathogens. Its identification within both most represented and fastest growing subclasses might reflect a trend in the technologies aiming to substitute conventional pesticides by microorganisms. Nevertheless, the growth of the trend is modest, probably reflecting low cost-efficiency and high specificity of these pest protection means compared to low-cost and relatively wide pest coverage of conventional pesticides.

The CAGR of IPC subclass C12R, related to microorganisms and their derivatives, is approaching 10%, potentially becoming an alternative to traditional pesticides.

Figure 4.4 Comparing the number of international patent families and the CAGR of each IPC subclass in the Non-pesticide pest and disease management field



Note: The data statistics are based on the number of international patent families published since 2004. The CAGR is calculated using the number of international patent families published from 2017 to 2021.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Technology at a glance: using microorganisms as pesticide replacement

Patents related to using microorganisms as pesticide replacements encompass various technologies, including the growth and production of beneficial microbes or their products, and the selection of suitable microbial species. Their functions include fighting pests and preventing or treating diseases. The application fields include use in soil, plants and seeds (Table 1).

Table 4.1 Example of patents related to using microorganisms as pesticide replacement

Technology group	Publication number	Title
Growth and production of beneficial microbes or their products	WO2018/049146	Novel cultivation system for the efficient production of microorganisms
Growth and production of beneficial microbes or their products	WO2018/049182	Distributed systems for the efficient production and use of microbe-based compositions
Selection of suitable microbial species	WO2010/015634	Method for screening for a plant protectant
Selection of suitable microbial species	WO2014/046553	Methods of screening for microorganisms that impart beneficial properties to plants
To fight pests	WO2021/211677	Compositions and methods to reduce insect pests
To fight pests	WO2018/208736	Compositions and methods to reduce the population of wheat-stem sawfly and hessian fly
To prevent or treat diseases	WO2008/056653	Microorganism capable of controlling plant diseases and plant disease-controlling agent using the microorganism
To prevent or treat diseases	CN103484376	Trichoderma spp. Strain antagonizing soil-borne diseases
Formulation for application to soil	IN0923/DEL/2009 (Application number)	Fungal bioagent and vam encapsulated alginate beads and its application thereof as biocontrol agent and biofertilizer soil borne plant pathogens.
Formulation for application to soil	CN108690815	Microbial composite organic fertilizer for preventing and controlling wheat scab, and preparation method thereof.
Formulation for application on plants	WO2021/123698	Bio-control method for combating the propagation of phytopathogenic fungi and oomycetes.
Formulation for application on plants	WO2009/093409	Novel mycovirus, attenuated strain of phytopathogenic fungus, plant disease controlling agent, methods of producing mycovirus, methods of attenuating phytopathogenic fungus and methods of controlling plant disease.
Formulation for application on seeds (seed coating)	WO2021/091463	Preparations for enhanced biocontrol
Formulation for application on seeds (seed coating)	WO2007/032458	Seed coated with antagonistic microorganism, method of producing the same and method of protecting crop from diseases.

Source: WIPO.

Emerging technologies: formulation technologies

Non-pesticide pest and disease management innovations are centered on formulation technologies, with leading roles played by Bayer, BASF, Sumitomo Chemical, Sinochem, and Corteva

Non-pesticide pest control innovations can be divided into five distinct segments (Figure 4.5):

- biosynthesis & extraction
- formulation
- encapsulation
- traps
- other devices.

Most patents in this field are related to formulation technologies for pest control products. This diverse group encompasses compositions containing proteins, microbe-based agents, or chemical compounds that target pests through various mechanisms. These mechanisms include repellency, attraction (luring pests to traps) or biocidal effects.

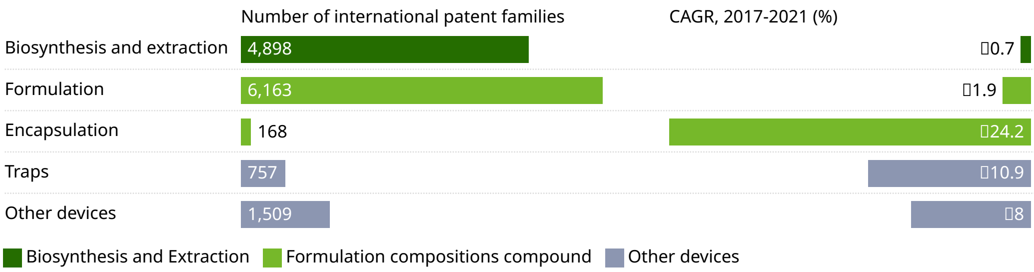
Biological agents in pest control come from various sources, all naturally occurring. This includes essential oils extracted from plants, proteins and hormones derived from plants, animals or microorganisms, as well as pest-pathogenic and plant growth-promoting microorganisms.

Despite the growing focus on environmentally friendly methods, as reflected in the SDGs and public preferences, there has been no overall growth in patent filings related to the biosynthesis and bio extraction of biological agents for pest control. A deeper analysis might be necessary to understand the specific trends within the various technologies under this category.

Similar to the observations in other segments, the number of patent filings associated with traps and other devices (including sprayers, dispensers, and biodegradable devices) has seen a decline during the 2017–2021 period.

Innovations in Non-pesticide pest and disease management focus on formulation and biosynthesis and extraction, but patent filings in these areas have not shown overall growth.

Figure 4.5 Innovations related to the Non-pesticide pest and disease management field



Note: The data statistics are based on the number of international patent families published since 2004. The CAGR is calculated based on the number of international patent families filed from 2017 to 2021.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

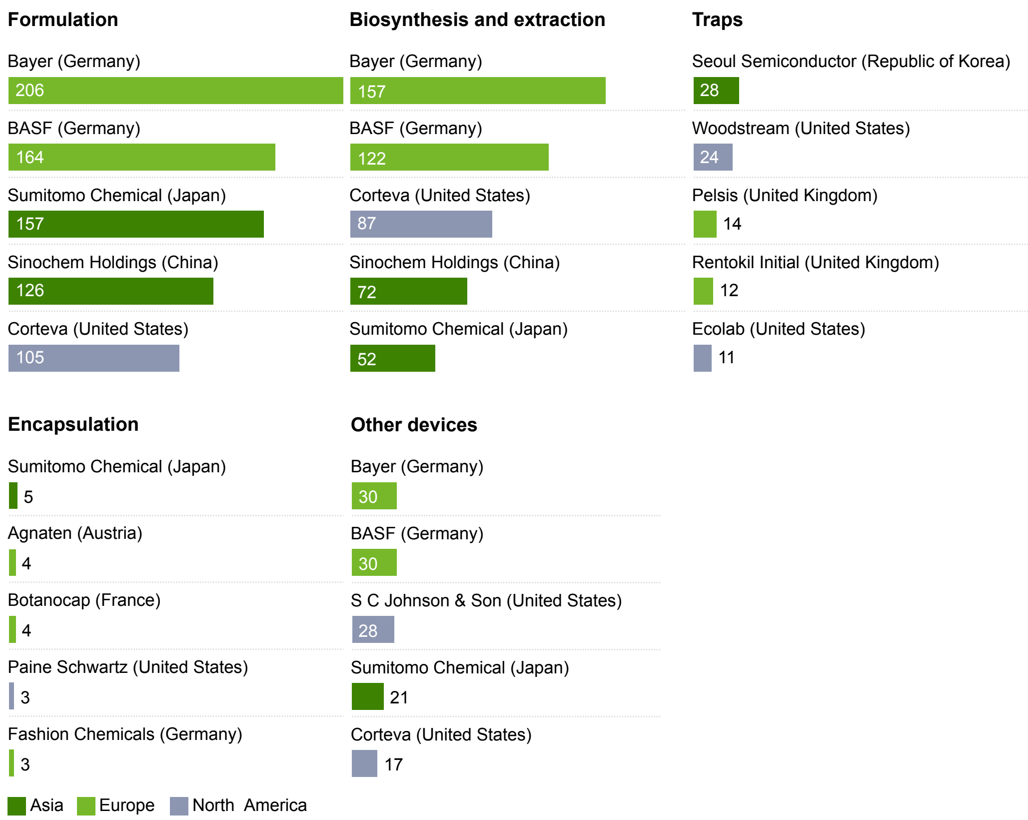
Germany dominates the *Non-pesticide pest and disease management* innovation landscape with chemical giants Bayer and BASF ranking first and second respectively in the fields of formulation, biosynthesis and extraction, and other devices. This highlights their leading role in developing advanced technologies across multiple segments.

United States company Corteva has secured a place within the top five in all three aforementioned areas, demonstrating its significant contributions to the sector.

Japan's Sumitomo Chemical also stands out, ranking within the top five in formulation, biosynthesis and extraction, encapsulation, and other devices. Notably, Sumitomo Chemical holds the first position in the encapsulation segment, despite not having a high total number of international patent families (Figure 4.6).

Bayer and BASF rank first and second, respectively, in the fields of formulation, biosynthesis and extraction, as well as other equipment.

Figure 4.6 Top applicants in five innovation areas of the Non-pesticide pest and disease management field



Note: The data statistics are based on the number of international patent families published since 2004.
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Deep dive

Non-pesticide pest and disease management strategies first target moths and legumes as pests and cultures of interest respectively

A semantic analysis of key concepts in *Non-pesticide pest and disease management* revealed the most targeted culture types and the most frequently mentioned pests.

Legume cultures, such as lentils and soybeans, were the most frequently mentioned culture type associated with pest control technologies. Interestingly, most mentioned cultures are linked to the food industry, apart from cotton, a non-food culture, ranking fourth (Figure 4.7).

The analysis of key concepts in Non-pesticide pest and disease management highlighted legume cultures as the most targeted.

Figure 4.7 Cultures of interest in the Non-pesticide pest and disease management field

Note: The data statistics are based on the number of international patent families published since 2004.
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

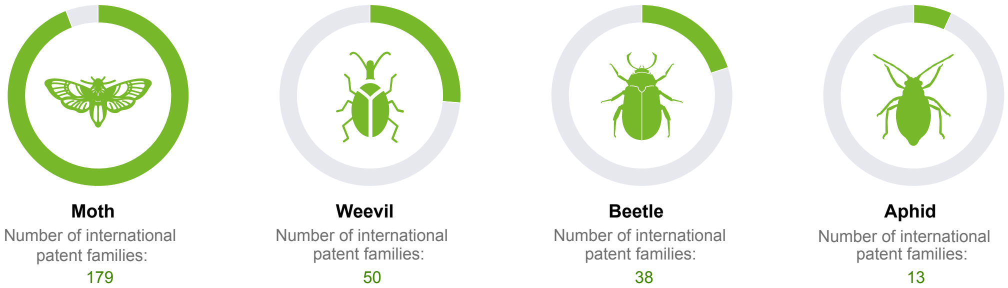
In the analysis of patents, moths were found to be the most frequently mentioned pest, while aphids were mentioned the least when pests were specified. These statistics may not accurately represent the true significance of pest management in the agribusiness sector. Although moth species have the potential to cause damage, they are generally not considered as big of a threat as aphids or beetles (Figure 4.8).

The majority of patents that mention these pest categories describe specific methods and compositions that are designed to target particular species of pests. This emphasis aligns with the nature of species-specific attractants like pheromones. However, some patents reveal formulations of pheromones without explicitly stating which pests or cultures they are targeting. These patents often focus on protecting the chemical formula and derivatives of synthetic pheromones used for specific pest control, which are typically further explained in the patent description.

In contrast to pheromones, allelochemicals and natural pesticides (such as essential oils and microorganisms) generally have a broader range of targets. While pheromones act as attractants, innovations related to allelochemicals primarily focus on repellents that deter various insects, including aphids, beetles, worms and bugs.

The analysis of key concepts in Non-pesticide pest and disease management highlighted moths being the most frequently mentioned pest in patents.

Figure 4.8 Targeted pests in the Non-pesticide pest and disease management field



Note: The data statistics are based on the number of international patent families published since 2004.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

5 Alternative nutrient sources for human food

The challenges posed by population growth and resource limitations globally has led to the development and promotion of alternative nutrient sources to traditional foods. Creative food solutions as sustainable alternatives include plant-based alternatives, insect proteins, precision and biomass fermentation, cell-based meat, and molecular farming. This chapter summarizes the patent landscape of the Alternative nutrient sources for human food field and provides an in-depth analysis of innovations in cultivated, lab-grown meat.

Global overview

An aggressive area for patent filing

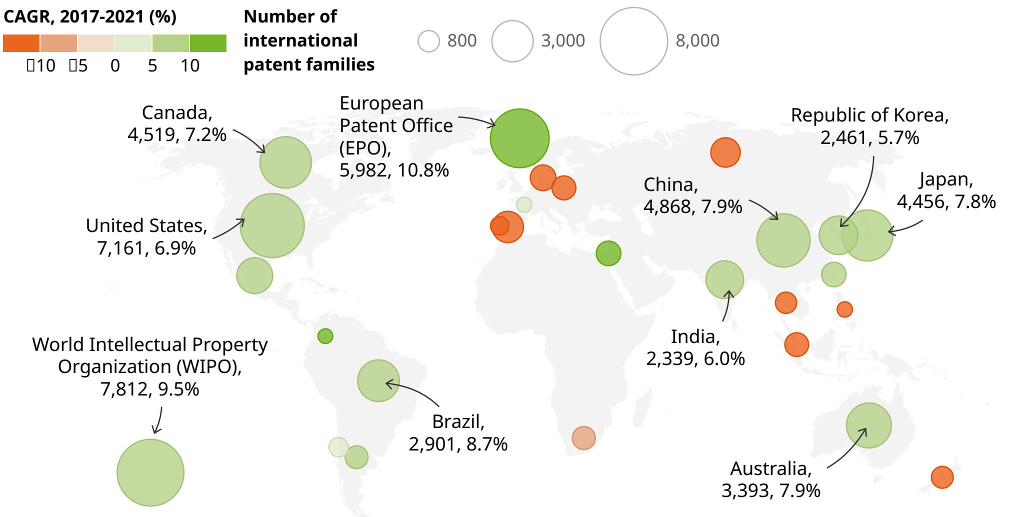
In recent years, there has been a significant shift towards innovative solutions aimed at providing alternative proteins to replace traditional animal products such as meat, seafood, eggs and dairy. A growing number of startups are focused on developing new technologies for alternative protein sources, reflecting a growing interest in sustainable food options. This trend is further highlighted by the increasing amount of venture capital being invested in the industry, with the successful IPO (Initial Public Offering) of Beyond Meat in 2019 acting as a catalyst for further investment. Notably, high-profile investors like Leonardo DiCaprio, Ashton Kutcher, and the Twitter co-founders Biz Stone and Evan Williams have shown support for this movement through private funding. The influx of funding has led many FoodTech startups to achieve unicorn status, with a significant portion of these companies specializing in alternative meats, as well as egg-free and dairy-free products.

Analysis of 10,173 international patent families indicates a dual dynamic of patent filing related to the *Alternative nutrient sources for human food* field. First a CAGR calculation from 2014 to 2019 show a flat dynamic (+0.4%). Then CAGR grows up to +7.2% from 2019 to 2021, highlighting a clear gain in interest for the field starting from 2020 (Figure 2.22).

The global filing trend for the *Alternative nutrient sources for human food* field shows PCT (WIPO) filing as the most popular choice, with 7,812 international patent families. The United States follows closely with 7,161 international patent families, and Europe (EPO filing) comes in third with 5,982 international patent families. Asia is also a significant contributor, with China leading with 4,868 international patent families, followed by Japan with 4,456 international patent families, the Republic of Korea with 2,461 international patent families, and India with 2,339 international patent families. Oceania and Latin America and the Caribbean are not far behind, with Australia holding 3,393 international patent families and Brazil with 2,901 international patent families. It is worth noting that non-international patent families were not included in this analysis, which could potentially impact the overall influence of Asian jurisdictions in the patent filing landscape (Figure 5.1).

PCT filings lead in Alternative nutrient sources for human food, followed closely by the United States, Europe, and Asian countries.

Figure 5.1 Top filing authorities in the Alternative nutrient sources for human food field



Note: The data statistics are based on the publication jurisdictions and the earliest publication year, encompassing the number of international patent families published since 2004. The CAGR is calculated using the number of international patent families published from 2017 to 2021.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

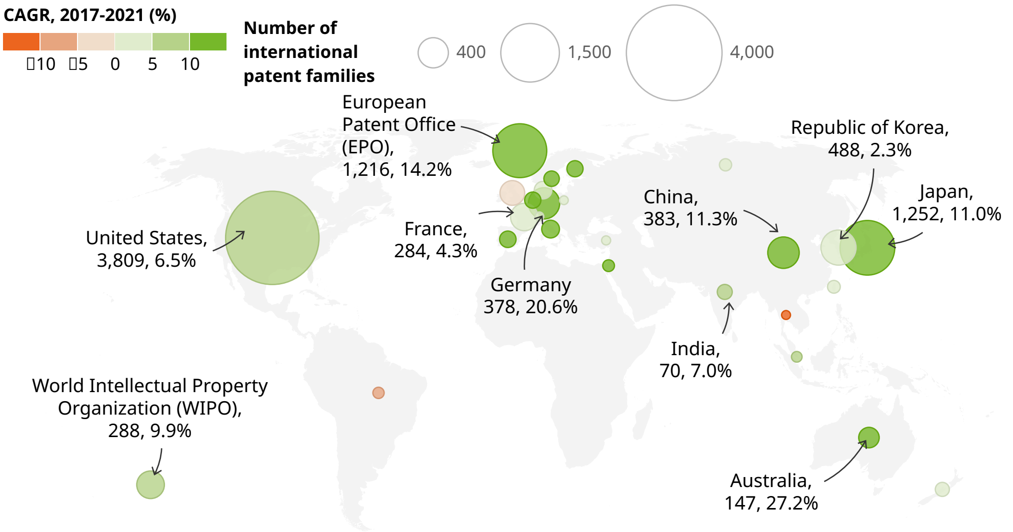
Inventive regions

North America as the frontrunner in patent filing with growing investments in Asia and Europe

According to Figure 5.2, the United States is the global leader in R&D for alternative nutrient sources, holding a total of 3,809 international patent families. Following behind is Japan with 1,252 international patent families, and EPO with 1,216 international patent families. Both Asia and Europe are experiencing substantial growth in this sector, with CAGR between 2017 and 2021 exceeding 10% for several countries. Specifically, Germany has shown an impressive growth rate of 20.6%, while the EPO has also a CAGR of 14.2% from 2017 to 2021. China and Japan have also demonstrated strong growth rates of 11.3% and 11.0% respectively.

The United States leads R&D in Alternative nutrient sources for human food, followed by Japan and the EPO, with significant growth in Asia and Europe.

Figure 5.2 Top first priority jurisdictions in the Alternative nutrient sources for human food field



Note: The data statistics are based on the first priority jurisdictions and the earliest publication year, encompassing the number of international patent families published since 2004. The CAGR is calculated using the number of international patent families published from 2017 to 2021.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Regional and national innovative strategies for Alternative nutrient sources for human food

Sustainable protein consumption is a major concern worldwide leading to continuous investments in the development of alternative protein sources, as per the following examples:

Türkiye

Türkiye promotes R&D activities on alternative production methods, such as making use of fatty acids by producing microalgae from seaweed, obtaining animal protein from resources of animal origin with low economic value.[1] Poultry other than chicken increasingly contributes to meeting animal protein needs. Türkiye has recently been making headlines in the poultry sector for the growth of turkey and goose breeding in addition to its success in chicken breeding. In addition, the consumer trend towards buying poultry meat in addition to chicken has increased the consumption of duck and goose meat, therefore diversifying alternative protein sources and extending the production of legumes as an alternative source of protein and ensuring their further consumption at reasonable prices.

Canada

In 2021, AAFC (Agriculture and Agri-food Canada) announced CA$4.3 million to support Canada’s pulses and special crops farmers to meet growing global consumer demand for sustainable, high-quality plant-based proteins. By increasing the market for Canadian-made pulse products, these investments encourage more farmers to add the nitrogen-fixing crops into their rotations, thereby increasing residual nitrogen in the soil and reducing the need for synthetic nitrogen fertilizers for subsequent annual grain crops.

1 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).

Dominican Republic

In the Dominican Republic, there is a need to make changes in the food culture of the population in general[2]; produce products with a healthy and affordable agricultural base for the entire population; design and implement public policies to control the adequate use of foods rich in carbohydrates, saturated fats and proteins; educate from home, following later in schools and universities; work on the plateau of gastronomy and get all sectors involved; carry out awareness campaigns in all available media (social networks, radio, TV, fairs, community meetings), delivering the message of the importance of consuming a healthy diet.

It is important to adapt the change in food culture to the characteristics of the different population groups, and focus on the most vulnerable groups: rural population, women, youth and children, etc. In this sense, the Dominican Republic suggests creating contents culturally adapted to each population group to achieve an effective behavior change.

European Union

For the European Union, caught fish, farmed fish and seafood are a source of high quality and affordable protein with a relatively low carbon footprint.[3] Sustainable fishing and managed fish stocks are essential to food security for many people and to maintaining the economic basis of fishing communities. These actions are also key to protecting ocean biodiversity and fighting against climate change.

The Common Fisheries Policy is bearing positive results and commits to step up efforts to bring fish stocks to sustainable levels. As announced in the Biodiversity Strategy, in February 2023, the European Commission has presented an Action Plan to conserve fisheries resources and protect marine ecosystems. This Action Plan will contribute to the production of sustainably managed and harvested fish of high quality and affordable protein.

Horizon Europe is the European multi-annual framework program for R&I (2021–2027), via which a diversity of actors, disciplines, sectors and locations are being supported to gain knowledge and develop impact driven innovation relevant to agriculture and food, like nature-based and agroecological approaches, alternative proteins and digitalization.

Top players

Unlike startups, main players' portfolios are broadened to insect, algae and plant-based proteins

In 2021, the global meat market was valued at USD 1.33 trillion, making it an attractive target for those looking to capture market share through innovative technologies. On the other hand, the global markets for alternative dairy and vegan meat products were valued at USD 19.66 billion and USD 5.6 billion, respectively, with projected annual growth rates of 13.3% and 15% over the next six years.

Among the top 30 applicants for international patent families in the field of Sustainable Nutrient Sources, corporate applicants hold 18 positions. In contrast, only two positions are held by universities and research institutions: the Commonwealth Scientific & Industrial Research Organization (CSIRO) of Australia and Jiangnan University of China (Figure 5.3).

Pioneer Hi-Bred International ranks first, with 373 international patent families. Pioneer Hi-Bred International has a diverse and innovative patent portfolio in the field of *Alternative nutrient sources for human food*. The company has developed a range of novel technologies and

2 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).
3 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).

products that aim to provide sustainable and nutritious alternatives to traditional food sources, including novel plant breeding techniques for enhancing the nutritional content of crops, such as biofortification of staple crops with essential vitamins and minerals; and biotechnological methods for producing alternative protein sources, such as plant-based proteins and cultured meat.

Nestlé ranks second, with 350 international patent families. Nestlé's patent portfolio for alternative nutrient sources including patents related to plant-based proteins, insect-based proteins, algae-based ingredients and other alternative nutrient sources. These patents may cover various aspects of the production, processing and formulation of these alternative nutrient sources, as well as their applications in food products. For example, Nestlé may have patents related to the extraction and purification of proteins from plants or insects, the development of new food products incorporating these ingredients, and the use of algae-based ingredients in functional foods and beverages.

DSM-Firmenich (Switzerland/Netherlands), and BASF (Germany) show similar patent portfolios in the field of alternative nutrient sources, which include:

- patented formulations of nutrient-rich products derived from alternative sources, such as algae-based omega-3 supplements, insect protein bars and plant-based protein powders
- patented processes for the extraction and purification of nutrients from alternative sources such as algae, insects and plant-based proteins, ensuring the preservation of nutrient quality and bioavailability
- patents covering the development of novel biotechnologies for the production of alternative nutrient sources, such as genetically engineered microorganisms for the production of vitamins and amino acids.

These technologies enable the scalable and cost-effective production of essential nutrients, making them more accessible to a wider range of industries.

Bayer's portfolio relates to the development of plant-based proteins, such as those derived from soy, peas or other legumes, as well as patents related to the extraction and processing of algae-based nutrients, insect proteins and other unconventional sources of nutrients.

Some of the key patents in International Flavors and Fragrances' (IFF) portfolio include formulations for enhancing the taste and aroma of plant-based proteins, methods for improving the texture and mouthfeel of cultured meat, and technologies for extracting and stabilizing flavors from algae and insects. Additionally, IFF's patent portfolio includes inventions related to the use of natural and sustainable ingredients in food products, such as plant-based emulsifiers, coloring agents derived from fruits and vegetables, and flavor enhancers sourced from seaweed and mushrooms. These patents demonstrate IFF's dedication to creating delicious and healthy food products that are in line with consumer preferences for clean label and environmentally friendly ingredients.

In addition to complementary solutions for algae-, insect- and plant-based proteins, Sinochem's developed sustainable packaging material made from biodegradable plant-based polymers, to reduce the environmental impact of food packaging.

Kotobuki also developed novel processes for producing food-grade proteins from algae and insects, as well as methods of fermenting certain types of grains or legumes to enhance their nutritional content and digestibility, making them suitable for inclusion in human diets, and for brewery products. Kotobuki is also involved in the development of a new type of packaging material that extends the shelf life of alternative nutrient sources, reducing food waste and ensuring products remain fresh and nutritious for longer periods.

Cargill's developed an extensive expertise in pea and algae-based proteins, to be used as meat and dairy product substitutes. They also developed alternative sweeteners like stevia or monk fruit extracts. Additionally, Cargill may have patents for technologies related to the extraction and processing of these alternative nutrient sources, as well as patents for formulations and applications in various food products.

Novozymes' patents mostly focus on novel enzymes for fermented and dairy product processing, including a brewing method using fungal or bacterial proteases as well as lactic bacteria for texturizing food products, and enzyme variants with improved milk-clotting properties.

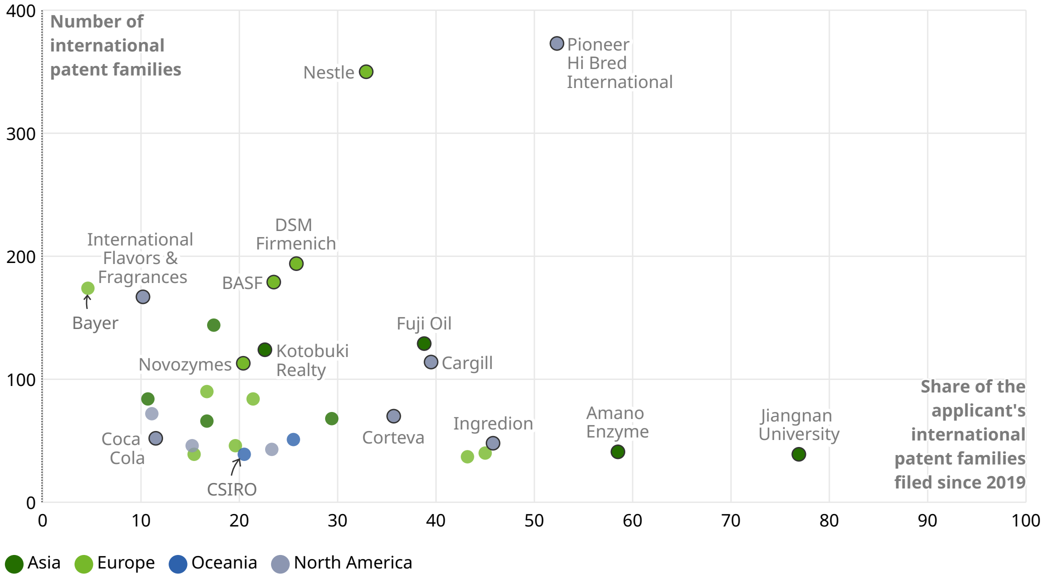
Startups are strategically promoting their meat-alternative products by forming partnerships with fast-food chains and traditional retail stores. For example, Impossible Foods has partnered with White Castle in the US to offer the "Impossible Slider" (a plant burger that cooks, smells and tastes like meat), while Beyond Meat's plant-based burger patties are available in supermarkets such as Kroger, Target and TESCO in the United States and the United Kingdom.

Recognizing the potential of disruptive trends in the industry, traditional meat-processing companies like Tyson Foods and General Mills have begun investing in alternative protein innovations through venture capital funding and the development of their own meat-alternative products. Other companies, such as Perdue Farms, Hormel Foods, and Smithfield, are also entering the market with plant-based products like nuggets and burger patties.

Some companies have chosen to enter the market through acquisitions, with Pinnacle Foods acquiring Gardein in 2014, Maple Leaf Foods purchasing Field Roast Grain Meat Co., and Nestlé acquiring Sweet Earth Foods in 2017.

Companies like Pioneer Hi-Bred International, Nestlé, DSM-Firmenich and BASF have developed innovative patent portfolios for Alternative nutrient sources in food products.

Figure 5.3 Top applicants in the Alternative nutrient sources for human food field



Note: The data statistics are based on the number of international patent families published since 2004.
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Emerging technologies: creative food solutions

The food industry is driving innovation in alternative food sources through various technologies, including plant-based products, insect proteins, precision fermentation, biomass fermentation, cell-based meat, and molecular farming

There is a wide range of *Alternative nutrient sources for human food* and products that startups have come up with. These can be divided into the following six technology groups:

Plant-based alternatives for meat (WO2022/253643, WO2020/205274), seafood (WO2022/136577), egg (WO2021/219967), and dairy (WO2022/148567, WO2018/191629, DE202023107333) products are made from a variety of plant sources such as soy, wheat, peas, beans, duckweed and algae. This cutting-edge technology group has several established products on the market. Innovative plant-based protein alternatives have been at the forefront of technological advancements in the food industry, with a wide range of products already established in the market. However, there has been a noticeable lack of innovation in recent years. These patented inventions include protein extraction processes, protein incorporation in food products and the use of proteins as substitutes for traditional ingredients.

Insect proteins for human consumption (WO2022/250526, WO2022/089836), which are common in other parts of the world, are now gaining popularity in the western world. The European Commission has authorized three insect species for food consumption: the yellow mealworm, the house cricket and the migratory locust. Companies like Ynsect (WO2022/268910, WO2022/207866) are transitioning from producing insect protein for animal feed to human food production.

Precision fermentation (WO2023/141256) uses microorganisms to produce proteins from non-animal sources. Companies like Perfect Day (WO2020/219596, WO2020/061503, WO2021/168343, WO2020/219595) and The EVERY Company (owner of Clara Foods - WO2022/246284, EP3217807, WO2023/192957) are leading the way in producing animal-free milk and egg proteins for food companies.

Biomass fermentation (WO2023/208970, WO2019/122192, WO2013/192391) produces new types of proteins using specific microorganisms, which can be used to create alternative food products. Nature's Fynd offers meatless burger patties and dairy-free cream cheese made with their Fy Protein® derived from fungi. Solein®, a microbial protein produced from air and electricity by Solar Foods (WO2022/229504, WO2022/229503), is currently seeking novel food approval from the European Commission.

Cell-based meat (WO2022/229501, WO2023/275304, WO2023/049750) is grown from single cells taken from animals in bioreactors, eliminating the need for traditional farming practices. Singapore recently approved the commercialization of cell-based chicken from Good Meat (WO2020/252388, US20050010965), a branch of Just.

Molecular farming (WO2004/071467, WO2008/040599, WO2009/108180) involves genetically modified plants used as bioreactors to produce specific proteins, with companies like Moolec Science (WO2024/003668) and Nobell foods (US11685928) developing innovative products in this field such as plant-based bovine protein and cheese made from plant-based casein.

Technology at a glance: dairy protein from precision fermentation

Perfect Day uses precision fermentation technology, where genetically engineered microorganisms ferment a mixture of water, nutrients, and sugar to produce milk proteins (whey protein) that can replace traditional dairy proteins. These microorganisms are equipped with DNA that enables them to produce pure animal proteins. The whey protein produced can replace animal-based dairy proteins in products such as ice cream, bread, cookies, cream and milk, thereby reducing the need for methane-emitting dairy cows.

Since this protein is similar in taste and quality to animal-derived proteins, it can be incorporated into the production processes of various food products without altering their taste or texture or affecting consumer preferences. Therefore, this innovation could have a significant impact.[4]

Perfect Day's patent WO2020/219596 describes recombinant milk proteins with non-native post-translational modifications (PTMs) and their applications in food products. These recombinant milk proteins are produced using genetic engineering techniques and have better solubility, making them more suitable for the production of dairy-like beverages and other food products.

4 WIPO. Green Technology Book: Solutions for climate change mitigation. (https://www.wipo.int/green-technology-book-mitigation/en/).

Another patent, WO2020/081789, relates to methods and compositions for producing food products using recombinant components, particularly those produced by recombinant microbial host cells. This patent specifically addresses the elimination or modulation of esterase activity in these cells, ensuring that the esterase activity in the food product is essentially eliminated or modulated compared to corresponding food products. This approach allows the recombinant components to function better during food production while avoiding potential adverse effects caused by esterase activity. The patent also discusses genetic modifications in recombinant microbial host cells to eliminate or modulate esterase activity or expression, optimizing the use of recombinant components in food products.

Through these patents and technologies, Perfect Day not only provides environmentally friendly and sustainable dairy protein alternatives in food products but also addresses issues related to traditional dairy allergies and enhances the solubility and functionality of milk proteins in various applications. These innovations significantly reduce dependence on livestock, lower greenhouse gas emissions and offer consumers healthy and high-quality dairy alternatives.

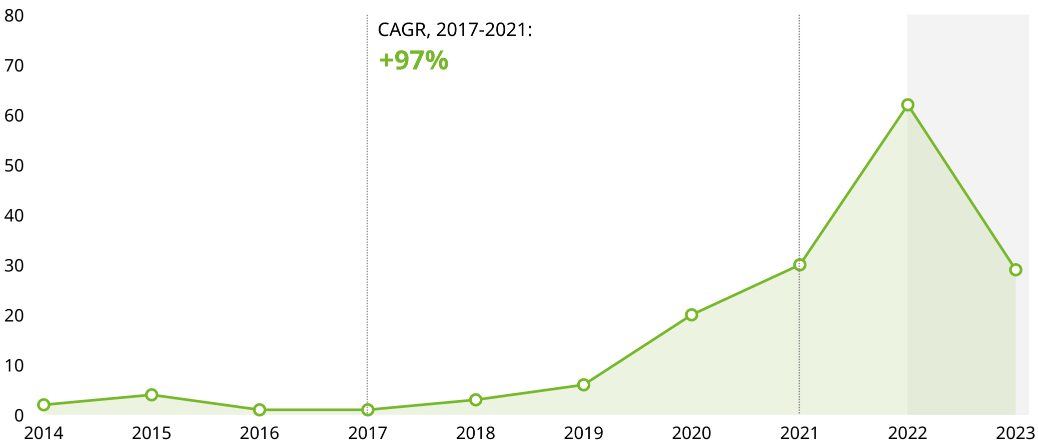
Deep dive: cell-based meat

Industrial startups are leading innovation in cell-based meat technology, with substantial patent activity in the US, Europe, and Asia

Cell-based meat alternatives is a cutting-edge Food technology that has the power to revolutionize the traditional meat industry. Cell-based meat production has seen a significant increase in patent filings since 2019, with a CAGR of 97% from 2017 to 2021 (Figure 5.4).[5] Also known as cultured meat or clean meat, this innovative process minimizes animal harm and environmental damage when compared to traditional meat production methods. The patent landscape for cell-based meat includes various aspects of the technology, ranging from media composition to food formulations. This young technology shows promise for creating a more sustainable and ethical source of meat for human consumption.

Cell-based meat represents a cutting-edge food technology with the potential to transform the traditional meat industry.

Figure 5.4 Number of international patent families by first publication year in the cell-based meat field



Note: Data from 2022 are partial since non-international patent families (singletons) are excluded. 2021 is the last year for which complete data are available.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

5 The analysis of patent data in this section is based on the patent data related to cell-based meat from the Questel report: FoodTech: Patents and the rise of meat and dairy protein alternatives (https://www.questel.com/resourcehub/foodtech-patents-and-the-rise-of-meat-and-dairy-protein-alternatives/).

It has been shown that among the top ten key players in the field, there is a highest representation of industrial entities over academic ones. Please note that since non-international patent families are not considered in this analysis, the impact of academic institutions may be lower. Leading industrial players include well-known startups such as Upside Foods, Aleph Farms, Mosa Meat and Good Meat (a part of Eat Just), all of whom are strategically targeting major markets in the US, Europe and Asia with their patent coverage.

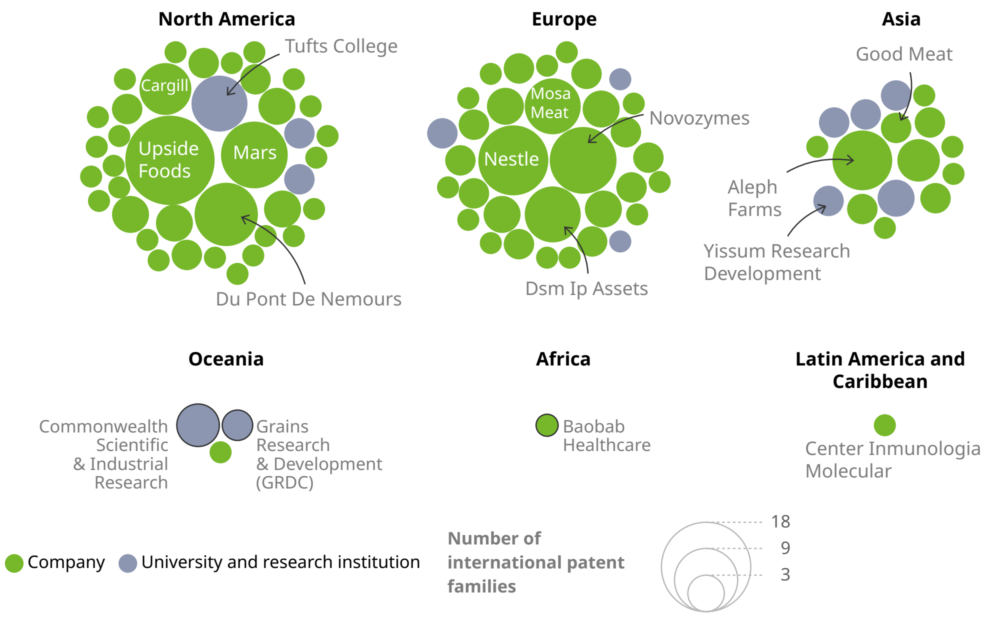
Additionally, academic players are Chinese universities focusing primarily on protecting their inventions within China. Yissum Research Development, affiliated with Hebrew University of Jerusalem in Israel, stands out for filing broad patent applications across multiple regions.

The industry is rapidly progressing, as evidenced by milestones such as Good Meat's approval to commercialize their cell-based chicken in Singapore and SuperMeat's opening of a cell-based chicken restaurant in Israel.

For Israel, animal protein consumption should be reduced in line with Ministry of Health recommendations to improve human health, increase national food security and decrease the environmental footprint of food production. Israel has the potential to be a world leader in the field of innovative foods such as alternative proteins, having Aleph Farms as a leading company worldwide. The government invests in sustainable healthy food startup companies and objective academic research, for example by the University of Jerusalem, as well as promoting the understanding of what sustainable food systems are, to continue reducing the consumption of animal proteins (meat, eggs, and milk products) (Figure 5.5).

Industrial entities outnumber academic institutions among the top players, with leading companies including startups like Upside Foods, Aleph Farms, Mosa Meat, and Good Meat.

Figure 5.5 Patent applicants in the cell-based meat field



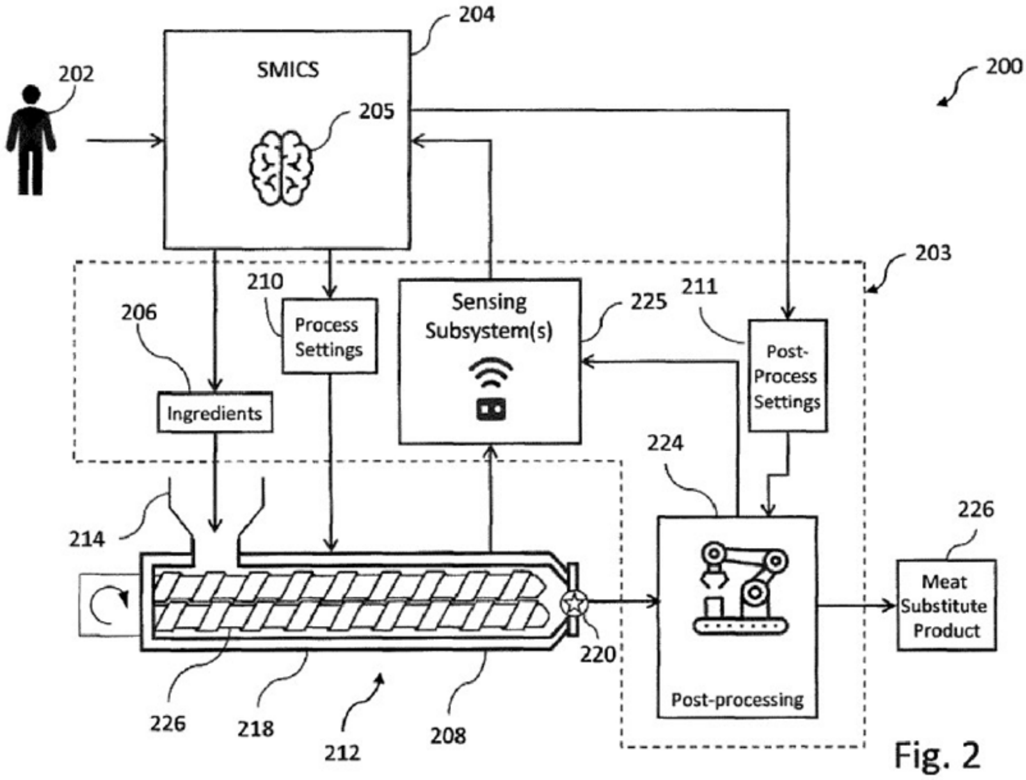
Note: The data statistics are based on the number of international patent families published since 2004.
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Technology at a glance: industrial-level meat analog production

Considering the shift towards protein alternatives, Innovative solutions are designed for industrial-level meat analog production.

The meat analog manufacturing machine consists of several interconnected units, each serving a specific function in the production process. Forefront is a large mixing chamber connected by a conveyor to an extruder forming the base of the meat analogs. Beyond the extruder are cooking stations where the formed meat analogs undergo heat treatment. Adjacent to the cooking stations is a cooling tunnel, where fans blow cool air onto the products, hastening the cooling process. Lastly, automated packaging machines stand ready to receive the cooled meat analogs. These machines deftly seal the products into vacuum-sealed pouches, ensuring their freshness and longevity.

Figure 5.6 An example system for producing alternative protein-based meat substitutes



Source: WO2022/012879.

Table 5.1 Example of patents related to cell-based meat production

Publication number	Title
WO2022/012879	Supervisory machine intelligence controls for production of meat substitutes
US5433968	Process for producing a simulated meat product
WO2020/208104	Meat analogues and meat analogue extrusion devices and methods
WO2021/136816	Method for making meat analogues by extrusion, and suitable extrusion die with a core

Source: WIPO

6 Predictive models in precision agriculture

The use of artificial intelligence and software development in precision agriculture helps farmers forecast market demand and optimize planting and irrigation plans, thereby enhancing the accuracy and efficiency of agricultural production. This chapter presents a detailed overview of the patent landscape and highlights the predictive model techniques that assist in crop cultivation and food processing.

Global overview

Fast-growing patent activity mainly focusing on North America

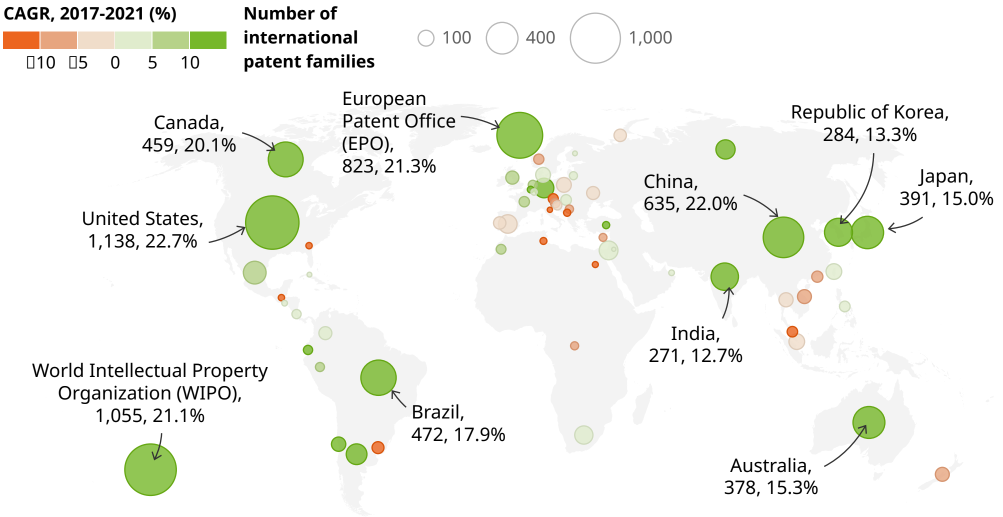
Analysis of data from 1,529 international patent families in the field of *Predictive models in precision agriculture* shows a substantial CAGR of +27.1% from 2017 to 2021, indicating a surge in interest in the subject matter (Figure 2.22).

The USPTO, WIPO and EPO are widely recognized as the leading global authorities for patent filings, with 1,138, 1,055, and 823 international patent families respectively (Figure 6.1). Asia is also rapidly emerging as a significant contributor in the field of *Predictive models in precision agriculture*. China leads the pack with 635 international patents, followed closely by Japan with 391 international patents and the Republic of Korea with 284 international patents. This trend highlights the region's increasing presence and influence in the global market.

On the other hand, North America sees Canada contributing 459 international patent families, while Latin America and the Caribbean are represented by Brazil with 472 international patent families. Oceania is also making its mark, with Australia filing 378 international patent families. It is important to note that this data only considers international patent families, which may not fully capture the impact of regional jurisdictions in Asia.

USPTO, WIPO and EPO are leading global international patent family filings, but Asia is quickly catching up.

Figure 6.1 Top filing authorities in the Predictive models in precision agriculture field



Note: The data statistics are based on the publication jurisdictions and the earliest publication year, encompassing the number of international patent families published since 2004. The CAGR is calculated using the number of international patent families published from 2017 to 2021.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

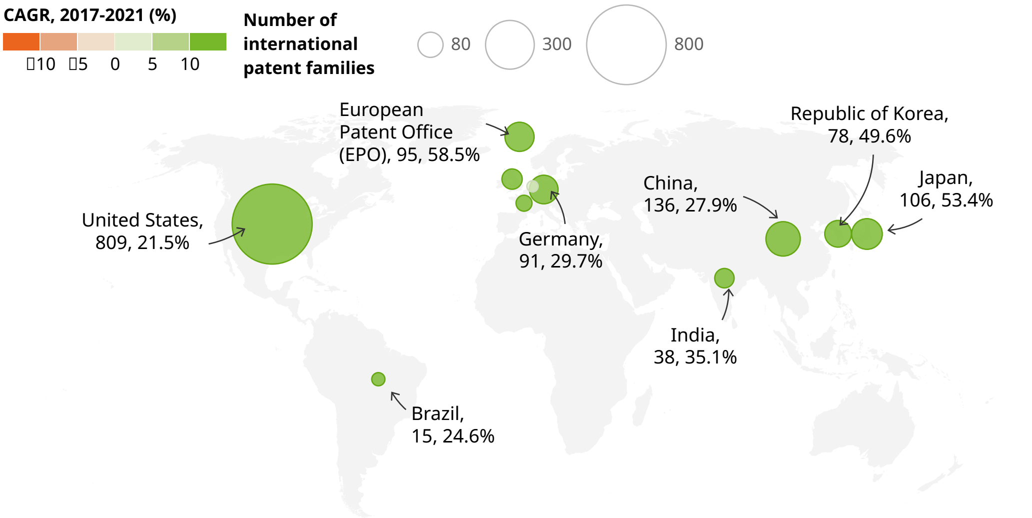
Inventive regions

North America as the innovation hub for Predictive models in precision agriculture

According to Figure 6.2, the United States is the leader in R&D for predictive models dedicated to the Agrifood sector, with a total of 809 international patent families. Following close behind is China with 136 international patent families, and Japan with 106 international patent families. All the regions have shown significant growth in this area, with a CAGR between 2017 and 2021, exceeding 20% for several countries. Specifically, EPO has seen a growth rate of 58.5%, Japan has experienced a growth rate of 53.4%, the Republic of Korea has seen a growth rate of 49.6%, India has grown at a rate of 35.1%, Germany has seen a growth rate of 29.7%, and China has grown at a rate of 27.9%.

The United States leads in R&D for Predictive models in precision agriculture, while Asia and Europe have shown significant growth.

Figure 6.2 Top first priority jurisdictions in the Predictive models in precision agriculture field



Note: The data statistics are based on the first priority jurisdictions and the earliest publication year, encompassing the number of international patent families published since 2004. The CAGR is calculated using the number of international patent families published from 2017 to 2021.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Regional innovative strategies for Predictive models in precision agriculture

North America

The United States boosts investments in science, evidence, and programs for effective conservation and climate-smart practices: The FDA is using the One Health Approach to address issues associated with food and public health, USDA is surveilling emerging zoonotic diseases to mitigate future pandemic risk, the National Oceanic and Atmospheric Administration (NOAA) is increasing data collection to model and predict the impact of climate change on fisheries production, and the National Aeronautics and Space Administration (NASA) is collaborating with USDA to share and apply space-based measurements of soil moisture to strengthen predictions of agricultural and climate trends and support research on the carbon cycle.

Europe

To assist partner jurisdictions to strengthen their food systems, the European Union is mobilizing various financial instruments, including the Neighborhood, Development and International Cooperation Instrument – Global Europe (NDICI-GE). Sustainable agriculture is part of the Global Gateway strategy, Europe's positive offer to the world to promote sustainable investments in view of the twin green and digital transition and human development – in cooperation with the European Union's Member States, financial institutions, development finance institutions and private sector.[1]

The United Kingdom government is pioneering the use of new tools to support its regulatory modernization program, including the use of open data and machine learning to strengthen its strategic surveillance capabilities. This system is used to predict internal and external risks

1 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).

to the United Kingdom's food system before they happen, complementing the effectiveness of import controls and incident management systems and helping to further protect consumers.[2]

Asia

In Asia, China is willing to deepen international Agrifood scientific and technological cooperation in "an open, inclusive, mutually beneficial and win-win manner; promote pragmatic cooperation in digital agriculture, green agriculture, smart food, green grain storage, agricultural machinery and equipment, molecular breeding and quality and safety; consolidate competitive resources of all parties on the basis of mutual trust; make full use of bilateral and multilateral agriculture and food security cooperation mechanisms; deepen South–South and triangular cooperation; strengthen North–South dialog; pursue innovative formats of experience sharing and talent exchange and cooperation; jointly improve global agricultural science and technology".[3]

There has been an immense growth of digital technologies in the agricultural sector in India in the last five years. Digital tools or apps based on AI for providing better farm management practices are gaining currency in India.[4]

Viet Nam is strengthening the application of digital technology in controlling precise agricultural farming systems and monitoring carbon footprints for key food value chains. Viet Nam is also involved in the building of digital information platforms for weather, climate, warning of risks caused by natural hazards, climate change, forecasting and warning of diseases and pests, and market information with easy access at provincial/commune levels. Finally Viet Nam is promoting the application of planting area/farm codes for all crops and livestock, application of digital technology in planting area management and traceability.[5]

In Bhutan, an ensemble of digital tools is planned to be developed and rolled out to provide crop and livestock advisory services, early warning on weather and incidences of pests and diseases. To assist service delivery, such digital platforms will also be designed to support agriculture and livestock extension agents. Digital tools to collect real-time data on farm conditions will also be rolled out to track the pulse and health of Bhutan's Agrifood systems.[6]

Indonesia, Nepal and Mongolia also support farmers' capacity, building on technology and innovation, including digital transformation. Tajikistan disseminates knowledge and encourages farmers to apply "smart" farm technologies and practices to increase yield and protect the environment. Among others, it promotes the rotation of cultivated plants, pasture management, animal, poultry and bee breeding and feeding, manure and agrichemicals management, and the use of digital technology in raising animals.[7]

Kuwait is investing in AI, advanced technologies and digitization to keep up with the progress in food systems.[8]

Türkiye is integrating new technological advancements, i.e. smart systems and AI, in national food production platforms to minimize human error in food production.[9]

2 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).
3 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).
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Africa

In Africa, Namibia aims to transform institutions for R&D and capacity building and to generate updated and open data. Emphasis is given to regularly conduct nutrition surveys to generate timely data on issues pertaining to wellness and survival, as the last survey was conducted in 2013. Zimbabwe aims at attracting youths to agriculture, "making agriculture sexy" through digitalization and other smart technologies that reduce that reduce drudgery.[10]

Latin America and the Caribbean

In Latin America, Uruguay is promoting the complete digitalization of agriculture, with special emphasis on the use of information and computing technologies by medium and family producers, as well as Micro, Small and Medium Enterprises (MSMEs) that process and market food.[11]

Oceania

In Oceania, Fiji promotes the use of block chain technology and digitalization to help to engage younger people in the food system, as for example in the use of drones for monitoring land-use changes or digital devices to measure changes in the ocean temperature. Fiji will also provide accessible digital platforms that can provide information and guidance to producers/end-users for the design, planning and implementation of their activities and to enable e-trade.[12]

Top players

Mixed panorama between AgriTech pure players and IT corporate heavyweights

The predictive model segment is largely dominated by industrial actors, with 90% of the market share. The top players in this segment originate from the United States, Germany and Japan, with global machine manufacturers and agrochemical companies leading the way (Figure 6.3).

As a global main actor for AgriTech in general, Deere is also the main innovator of predictive computational models as well as their integration within automated machine controls, holding 116 international patent families. Deere holds patents covering predictive crop state and characteristic mapping, predictive nutrient mapping, predictive harvesting models for machine control, predictive yield mapping and more. Deere exhibits a strong and diversified portfolio. However, this portfolio only shows extensions mainly in Brazil and Europe to a lesser extent.

Bayer and BASF are two German chemical and agrochemical companies, holding 72 and 53 international patent families respectively in the field of *Predictive models in precision agriculture*, ranking second and third. Bayer developed machine learning-based systems for soil analysis, multivariate algorithms for yield prediction in horticulture, image processing for disease detection in plants, fertility prescription and more. BASF shows a large expertise in crop protection and pest control based on infestation predictions, weather image capture complemented by analysis algorithms and prediction models for formulation properties. Both portfolios are strong and diversified, with worldwide extensions.

Mineral Earth Sciences and Alphabet are both US companies specializing in cutting-edge technology. They hold 21 and 12 international patent families respectively in this field, ranking fourth and sixth. Mineral Earth Science offers a wide range of services including soil

10 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).
11 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).
12 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).

composition prediction, crop yield prediction, climate forecasting and plant imaging analysis. In contrast, Alphabet has developed a comprehensive suite of solutions tailored specifically for aquaculture and fish feeding industries.

TBG AG (Thyssen-Bornemisza Group) is a Swiss company which acquired DTN (former Telvent and Schneider Electric) in 2017. TBG AG currently holds 10 international patent families in this field, ranking eighth. Together with Iteris, DTN developed models for soil compaction from diagnosis and prediction of soil and weather conditions to ultimately improve ground performance.

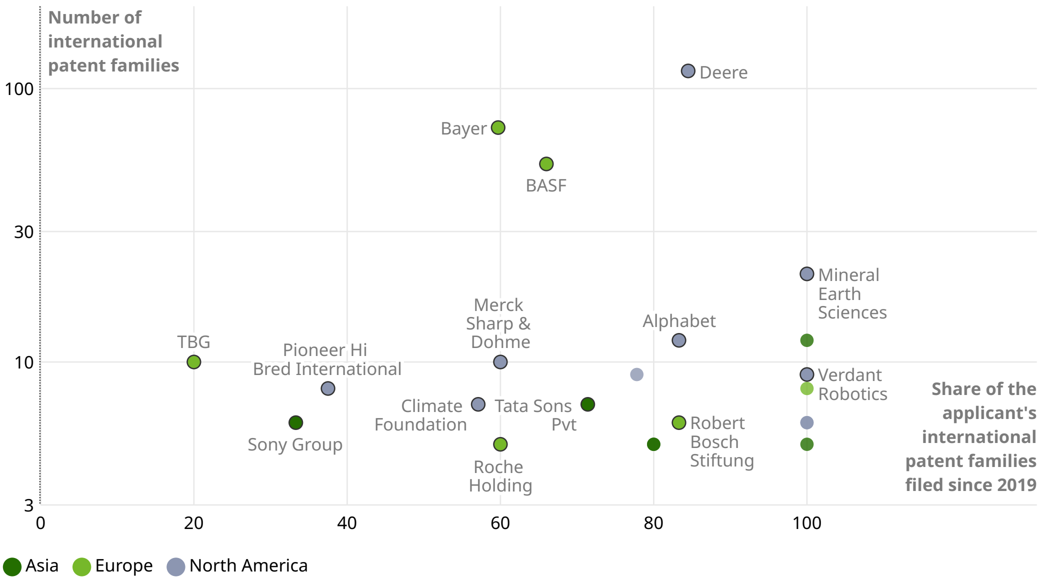
IBM (United States) shows a restricted portfolio related to the AgriTech domain from the development of IoT agricultural ecosystems, machine learning models for livestock value chain, crop disorder detection and systems for crop identification using satellite. It currently holds nine international patent families related to *Predictive models in precision agriculture*, ranking ninth.

TATA Sons PVT is an Indian actor involved in system development for crop features and quality management. Tata's portfolio is mostly extended to the United States, Brazil and Europe. It currently holds seven international patent families related to *Predictive models in precision agriculture*, ranking fourteenth.

Zheijiang University and Climate Foundation are the two academic players of this list. Zheijiang University currently holds 12 international patent families related to *Predictive models in precision agricultur*e, ranking fifth. This reflects the university's extensive expertise in yield prediction for crops and seeds, as well as in nitrogen measurement in soil content. Climate Foundation shows innovation in machine learning strategies for geospatial and weather data processing. It holds seven international patent families related to this technology, ranking thirteenth.

US-based Deere is the leading patent applicant for Predictive models in precision agriculture.

Figure 6.3 Top applicants in the Predictive models in precision agriculture field



Note: The data statistics are based on the number of international patent families published since 2004.
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Emerging technologies: data collection, processing, and controlling

Technologies for data collection, processing, and controlling systems are driving the adoption of Predictive models in precision agriculture

By analyzing the IPC subclasses within the field of *Predictive models in precision agriculture*, statistics were compiled on the number of international patent families associated with each IPC subclass, along with the CAGR of these subclasses from 2017 to 2021. Figure 6.4 illustrates the most-utilized technologies in the area of predictive models and their applications in agriculture.

Through the analysis of international patent families related to *Predictive models in precision agriculture*, the technologies involved in predictive models can be categorized into three main areas: data collection, data processing and controlling systems.

- *Data collection* forms the foundation of *Predictive models in precision agriculture*. By utilizing sensor data, accelerometers, captured images, cameras and communication interfaces, a variety of real-time information about the farmland can be obtained. This data is used to monitor crop growth conditions, soil moisture, temperature and other environmental parameters, thereby providing the basis for subsequent data processing and decision-making. The relevant IPC classifications for this technology include: G06T, G06V, G01N, G01S, G01C and H04N.
- In the *data processing* stage, predictive models analyze the collected data through machine learning, data classification and correlation techniques. These models can identify patterns and trends within the data, assess crop health, predict pest infestations and optimize the growth environment. The key to this stage is transforming complex raw data into valuable information that helps farmers and agricultural enterprises make informed decisions. The IPC classifications relevant to data processing include G06Q, G06N, G06F and G06K.
- *Controlling systems* are employed in precision agriculture to manage and regulate various agricultural processes. These systems can control non-electric variables and other critical parameters to optimize the operation of agricultural equipment and processes. For example, controlling systems can automatically adjust irrigation systems, fertilization equipment and pesticide sprayers, thereby enhancing the efficiency and effectiveness of agricultural production. The IPC classifications pertaining to controlling systems include G05D and G05B.

By integrating advanced predictive model technologies at every stage – data collection, data processing and controlling systems — agricultural enterprises can streamline operations, optimize decision-making processes and ultimately achieve better production outcomes. The application of these technologies not only enhances the precision and efficiency of agriculture but also promotes the shift towards intelligent and data-driven agricultural practices.

In the field of *Predictive models in precision agriculture*, the majority of patent applications are concentrated on data processing technologies, followed by data collection.

Predictive models in precision agriculture is mainly concentrated in the realm of data processing technologies and data collection.

Figure 6.4 Main technology trends of the Predictive model in precision agriculture field

Data Collection	Number of international patent families	CAGR, 2017-2021 (%)
G06T Image data generation	273	42.7
G06V Image recognition	259	51.6
G01N Analysing materials by their chemical or physical properties	195	18.3
H04N Pictorial communication	73	24.6
G01S Radio direction-finding	68	13.4
G01C Measuring distances	66	21.3

Data Processing	Number of international patent families	CAGR, 2017-2021 (%)
G06Q Data processing systems/methods	464	31.3
G06N Computer systems based on specific computational models	390	47.9
G06F Electric digital data processing	273	18.1
G06K Data recognition	199	40.3

Controlling System	Number of international patent families	CAGR, 2017-2021 (%)
G05D Controlling non-electric variables	183	36.6
G05B Control or regulating systems	124	14.9

Note: The data statistics are based on the number of international patent families published since 2004. The CAGR is calculated based on the number of international patent families filed from 2017 to 2021.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Applications of predictive models within the precision agriculture sub-domain was achieved by counting international patent families in-related IPC subclasses (Figure 6.5).

In recent years, there has been a significant increase in the use of predictive models to enhance soil management, plant culture and animal husbandry practices worldwide. This growth is evidenced by a CAGR of over 20% from 2017 to 2021. Innovations in the application of predictive models have revolutionized various sectors including soil working, horticulture, harvesting, planting, animal husbandry, aviculture, apiculture, pisciculture, fishing and animal trapping.

The integration of predictive models in soil management, includes *soil working* (A01B), *harvesting and mowing* (A01D) as well as *planting, sowing, fertilizing* (A01C). This has led to more efficient and sustainable agricultural practices. By analyzing data on soil composition, moisture levels and nutrient content, farmers can make informed decisions on irrigation, fertilization and crop rotation. This not only improves crop yields but also helps preserve soil health for future generations.

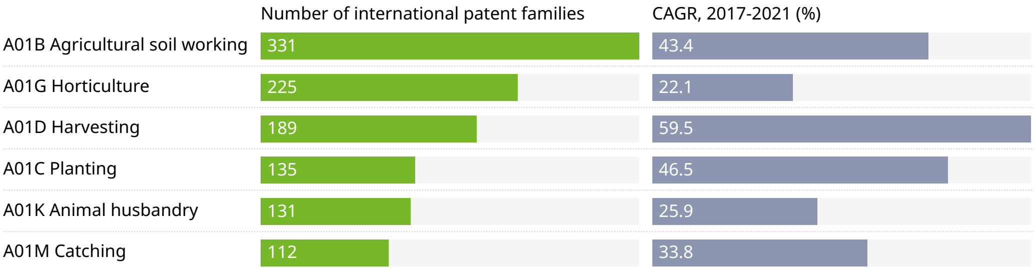
In *horticulture* (A01G), predictive models are being used to optimize plant growth and development. By monitoring factors such as temperature, humidity and sunlight exposure, growers can create ideal conditions for plant growth and minimize the risk of pests and diseases. This has led to higher-quality produce and increased profitability for farmers.

The use of predictive models in animal husbandry has also transformed the way livestock is managed. Animal husbandry, aviculture, apiculture, pisciculture and fishing have A01K as an IPC subclass, and catching, trapping or scaring of animals is A01M. By analyzing data on animal behavior, health and nutrition, farmers can identify potential issues before they escalate and take proactive measures to ensure the well-being of their animals. This has not only improved animal welfare but also increased productivity and profitability for farmers.

However, if predictive models are found in major areas of AgriTech segments, it fails to deeply penetrate and support FoodTech applications, for now (including food supply chain, food services, food delivery).

Innovations utilizing predictive models are rapidly expanding across various sectors in agriculture.

Figure 6.5 Main application areas of the Predictive models in precision agriculture field



Note: The data statistics are based on the number of international patent families published since 2004. The CAGR is calculated based on the number of international patent families filed from 2017 to 2021.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Technology at a glance: method, system and computer program for performing a pest forecast

Publication number: EP3482630

Applicant: Efos d.o.o.

Application Date: 13.11.2017

This invention presents a system and method for automated pest forecasting using data from traps, weather sources, and user inputs. By employing visual processing, machine learning, and decision-making algorithms, the system predicts pest populations and provides recommendations, improving crop protection efficiency.

The patent describes a novel approach to peat forecasting by integrating data from traps, weather sources, and user inputs. The system's automated processes improve the accuracy and timeliness of pest predictions, leading to more effective crop protection strategies.

The system offers advantages over manual pest monitoring methos by enabling real-time pest forecasts, reducing reaction time to pest pressure, and optimizing crop protection measures. It minimizes the risk of pest resistance, enhances prediction accuracy, and reduces operational costs.

Figure 6.6 Pest forecasting system

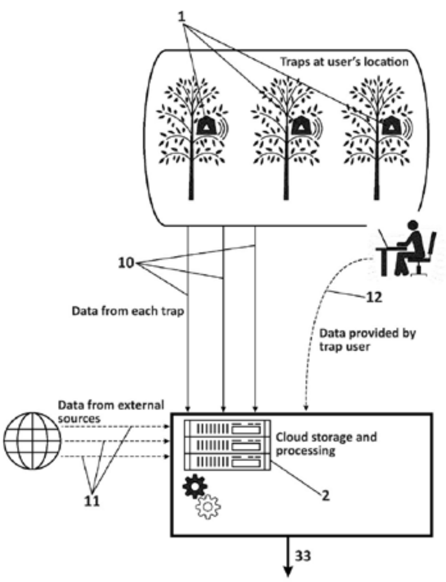


FIG. 1

Source: EP3482630.

7 Autonomous devices in precision agriculture

Exploring the application of autonomous machinery and robotics in precision agriculture enhances the efficiency of crop planting, management, irrigation, and harvesting. This chapter outlines the key trends in the patent landscape in this field and emphasizes utilizing autonomous guidance technology to assist machines dedicated to crop cultivation and food processing.

Global overview

A fast-growing area covering Europe and the United States

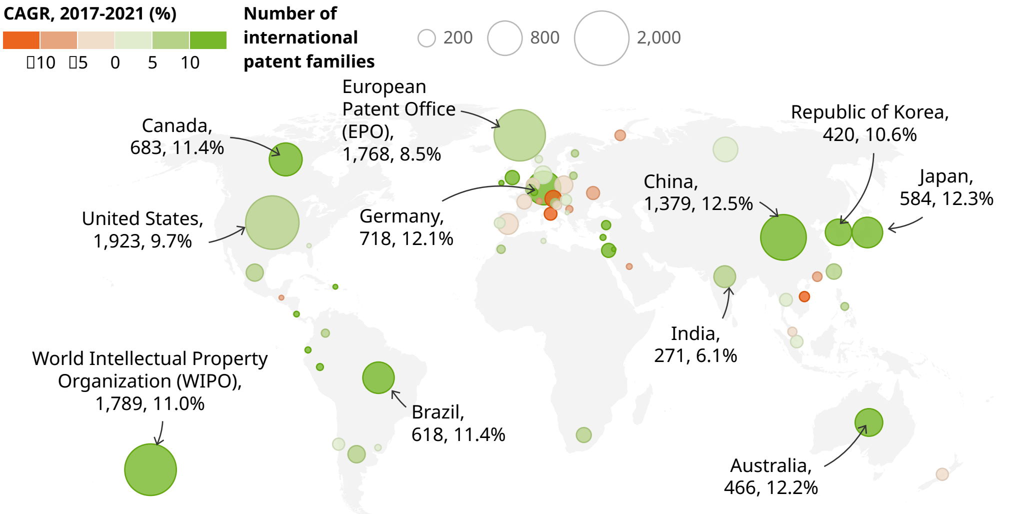
An in-depth examination of data collected from 3,593 international patent families in the field of *Autonomous devices in precision agriculture* reveals a notable CAGR of +10.4% from 2017 to 2021, indicating a substantial increase in interest in the subject matter (Figure 2.22).

The USPTO, WIPO and EPO are widely regarded as the top global authorities for patent filings, with 1,923, 1,789, and 1,768 international patent families respectively (Figure 7.1). In Asia, China takes the lead with 1,379 international filings, followed by Japan with 584 international filings and the Republic of Korea with 420 international filings. It should be noted that this analysis excludes non-international patent families, which could result in an underestimate of the influence of regional jurisdictions in Asia.

In Europe, Germany stands out with 718 international patent families, while in North America, Canada contributes 683 international patent families. Latin America and the Caribbean are represented by Brazil with 618 international patent families. Oceania is also making its presence felt, with Australia filing 466 international patent families.

The USPTO, WIPO and EPO are the top global authorities for international patent filings, with China leading in Asia.

Figure 7.1 Top filing authorities in the Autonomous devices in precision agriculture field



Note: The data statistics are based on the publication jurisdictions and the earliest publication year, encompassing the number of international patent families published since 2004. The CAGR is calculated using the number of international patent families published from 2017 to 2021.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

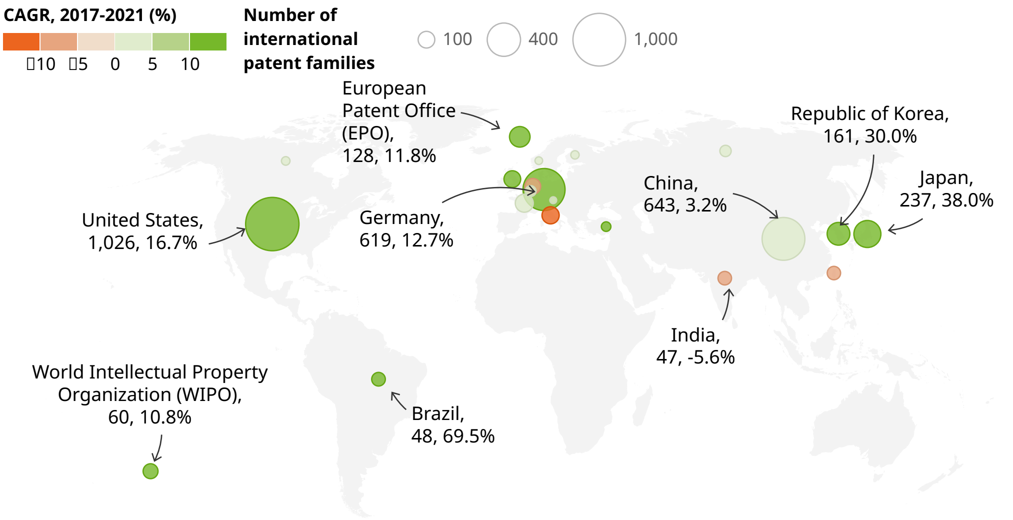
Inventive regions

China, the United States and Germany as main providers of solutions for autonomous guidance

In the realm of R&D for *Autonomous devices in precision agriculture*, Europe is leading the way with 1,279 international patent families dedicated to this field, largely attributed to the significant involvement of German industrial actors (Figure 7.2). Following behind, Asia boasts 1,177 international patent families. North America secures the third spot on the podium with 1040 international patent families, primarily due to substantial industrial investments in the United States. Analysis of CAGR in top locations worldwide reveals a growing interest in specific jurisdictions. For instance, Brazil shows a remarkable CAGR of +69.5%, while Japan follows closely behind with +38%. The Republic of Korea also demonstrates a notable CAGR of +30.0%, and the United Kingdom shows a CAGR of +20.1%, indicating an emerging regional interest in *Autonomous devices in precision agriculture* in these areas.

Europe, North America, and Asia lead R&D in Autonomous devices in precision agriculture, with growing interest from Brazil, Japan, the Republic of Korea, and the United Kingdom.

Figure 7.2 Top first priority jurisdictions in the Autonomous devices in precision agriculture field



Note: The data statistics are based on the first priority jurisdictions and the earliest publication year, encompassing the number of international patent families published since 2004. The CAGR is calculated using the number of international patent families published from 2017 to 2021.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Global effort in digitalizing agriculture

No specific policies or regulations directly favor the development of autonomous agricultural devices. However, a large effort on the global digitalization of agriculture tasks is conducted worldwide from several initiatives to globally gain access to modern farm machinery and equipment, ultimately promoting sustainable agriculture productivity.

Asia

In Asia, China promotes the revamping of Agrifood machinery and storage facilities. The Republic of Korea will use less fossil fuel in agriculture by increasing the use of renewable energy, and by developing electric agricultural machinery. In Japan, in order to reduce greenhouse gas emissions from agriculture, each location will take appropriate approaches for achieving carbon neutrality, including the electrification and hydrogenation of agricultural and forestry machinery as well as fisheries vessels. In Timor-Leste, efforts will also be made to sustainably manage tractors and other agricultural machinery to increase agriculture productivity and production. To enable this, the government will immediately embark on an exercise to map and catalog existing public and private agricultural machines to ascertain current coverage and conditions and strengthen regional maintenance centers and hiring services. The private sector will be involved to ensure mechanization is sustainable and production costs are minimized.[1]

Africa

In Africa, various strategies are used to renew farm equipment. Nigeria is developing regulatory standards for manufacturing agricultural machinery, to prevent the proliferation of inefficient machinery in the location. Uganda is improving its food systems infrastructure especially through efficient transport networks, technology, energy supply and agro-industrialization machinery supporting food system value chains. Burundi is improving the

1 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).

valorization of food crops through processing (machining), improving the quality and prices of agricultural products. This valuation gives farmers greater income that allows them to buy what they do not produce on their farms. Angola facilitates access to foreign exchange for the import of agricultural inputs (seeds, machinery and work tools, fertilizers and additives for animal feed, vaccines and fishing artifacts).[2]

Top players

Companies from Germany and the United States are leading the auto steering sector

Considering the top 50 players in the autonomous devices segment, industrial actors largely dominate the domain by 97% compared to academic ones. The majority of top players in the industry are primarily from Germany, making up 33% of the total. The top 10 players own 24% of the international patent families. They all are manufacturers of agricultural machinery (Deere, CNH Industrial, Kubota, etc.), with one German agrochemical company (Bayer) (Figure 7.3).

Deere is one of the few companies from the United States as a top actor (10%) but leads the field dedicated to *Autonomous devices in precision agriculture*, mostly from its large experience in autonomous harvesters. Deere currently holds 256 international patent families and exhibits a strong and diversified portfolio, with worldwide extensions.

Leading innovations in Germany, CLAAS is part of a huge German ecosystem of manufacturers of agricultural machines focusing on autonomous guidance. Together with Bernard Krone Holding, CLAAS targets their R&D on tractors and harvesters. Interestingly CLAAS shows a complementary patent portfolio with Amazonen-Werke H Dreyer and Horsch Holding, these companies being oriented toward sprayers, distributors and fertilizer spreaders. Another aspect of automation is covered by Baader Holding, which developed a full range of innovations dedicated to the automatic discharging, slaughtering and processing of livestock. Finally, Bayer, an agrochemical company, shows a diversified patent portfolio regarding many aspects of Agrifood domain. Bayer developed an interesting expertise in autonomous tillage practices as well as automatic systems for the evaluation of agricultural products. German top companies largely favor North American and European protection compared to Asia (Japan, India, the Republic of Korea) and Latin America.

CNH Industrial from the United Kingdom covers the automated guidance for tractors and harvesters. Despite a high number of patents with worldwide extensions in diversified areas, CNH's portfolio is less impactful with a lower number of non-self forward citations compared to Deere and CLAAS.

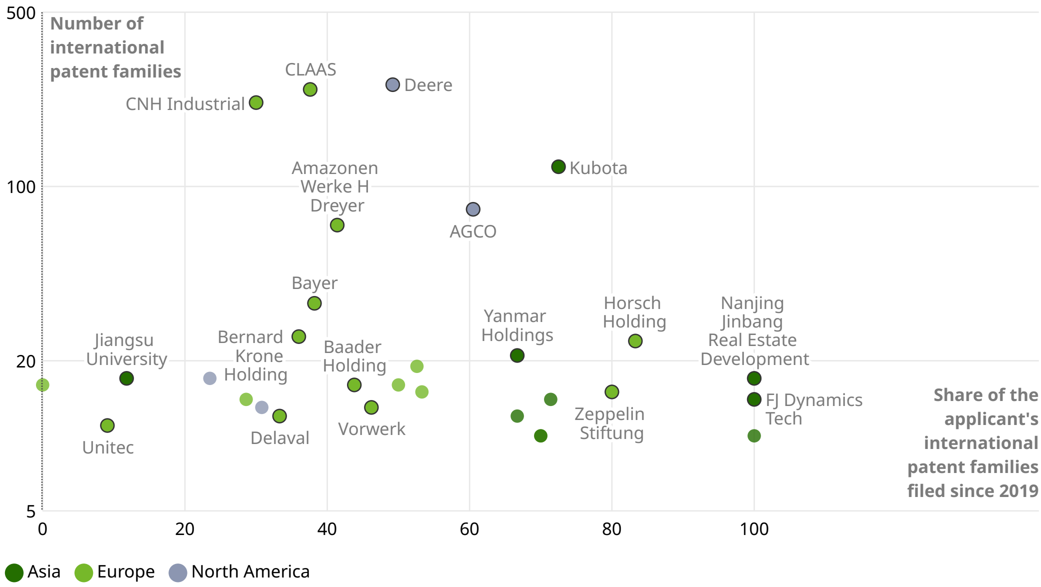
Kubota is also a major Japanese manufacturer of agricultural machines covering the field. With Iseki, both focus their development on automatic traveling using satellites, mostly for seeding and transplanting machines. Asian top companies majorly protect their innovations within Asian jurisdictions (China, Japan, India, the Republic of Korea), the United States and Europe, with additional few extensions in national phases.

Jiangsu University is the only non-industrial player, with patents dedicated to multiterrain intelligent mobile robots.

2 National Pathways Analysis Dashboard | UN Food Systems Coordination Hub (https://www.unfoodsystemshub.org/member-state-dialogue/national-pathways-analysis-dashboard/es).

Industrial actors, mainly from Germany, dominate Autonomous devices in precision agriculture, although US-based Deere leads the way.

Figure 7.3 Top applicants in the Autonomous devices in precision agriculture field



Note: The data statistics are based on the number of international patent families published since 2004.
Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Emerging technologies: controlling non-electric variables

The primary technologies are concentrated in the fields of data processing and controlling systems, with the technology of controlling non-electric variables experiencing the fastest growth in precision agriculture

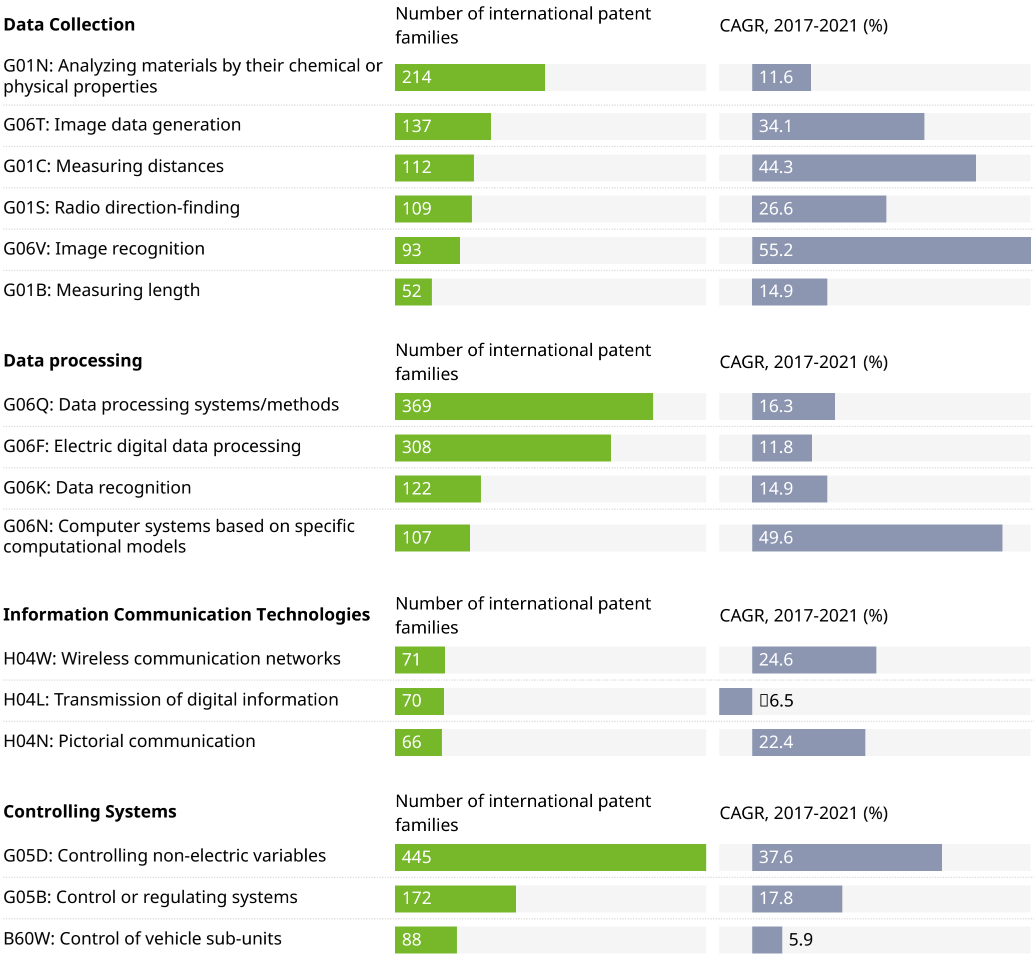
Through a comprehensive analysis of IPC subclasses, we were able to establish a global ranking based on the total number of international patent families. By calculating the fluctuations in document numbers from 2017 to 2021, we were able to identify the key technologies involved in precision agriculture with a focus on autonomous devices. These major technologies can be categorized into four primary domains: *data collection, data processing, information communication technologies and controlling systems* (Figure 7.4).

Among these domains, a significant concentration of patent applications is observed in the fields of data processing and controlling systems.

Notably, the IPC subclass G05D, which pertains to the technology of controlling non-electric variables, stands out. This subclass not only has the highest number of international patent families but also exhibits a remarkable growth in patent applications, with a CAGR of 37.6% from 2017 to 2021. The technology of controlling non-electric variables refers to the control and regulation of non-electrical parameters such as temperature, humidity, pressure, flow and chemical composition. In the context of precision agriculture, this technology finds applications in various scenarios, including environmental control, irrigation system management, fertilization and pesticide spraying. Such technology is crucial for optimizing agricultural practices, ensuring optimal growing conditions and improving resource efficiency. Given its substantial growth and pivotal role in precision agriculture, the technology of controlling non-electric variables is anticipated to be a major trend in the development of precision agriculture. Advances in this field are expected to significantly enhance the effectiveness and efficiency of autonomous agricultural devices.

There are many patents and strong growth for controlling non-electric variables , indicating it as a promising area for the future of precision agriculture.

Figure 7.4 Main technology trends of the Autonomous devices in precision agriculture field



Note: The data statistics are based on the number of international patent families published since 2004. The CAGR is calculated based on the number of international patent families filed from 2017 to 2021.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

The ranking of applications in the autonomous devices segment of the precision agriculture sub-domain was established by examining the number of IPC subclasses of each international patent family, as shown in Figure 7.5. The analysis revealed a significant growth rate of over +20% CAGR from 2017 to 2021, indicating a notable increase in the adoption of autonomous devices for tasks such as soil working (A01B), crop harvesting and mowing (A01D). Autonomous devices are also being utilized in other agricultural applications, however with very low CAGRs, such as crop planting and culture, as well as animal husbandry practices. Furthermore, the food supply chain (A22C, B01D), including transportation and storage, is also being targeted for robotization in order to improve efficiency and productivity within the industry (data not shown).

The adoption rates of tasks such as soil working, crop harvesting and mowing have significantly increased.

Figure 7.5 Main application areas of the Autonomous devices in precision agriculture field

	Number of international patent families	CAGR, 2017-2021 (%)
A01B: Soil working	969	24.2
A01D: Harvesting and mowing	816	22
A01G: Horticulture	671	1.1
A01K: Animal husbandry, aviculture, apiculture, pisciculture; fishing	453	0.6
A01C: Planting, sowing, fertilizing	431	13.3
A01M: Catching, trapping or scaring of animals	216	11.3

Note: The data statistics are based on the number of international patent families published since 2004. The CAGR is calculated based on the number of international patent families filed from 2017 to 2021.

Source: WIPO, based on patent data from Orbit Intelligence (Questel), March 2024.

Technology at a glance: method and apparatus for autonomous indoor farming

Publication number: WO2021/097368

Applicant: 80 Acres Urban Agriculture, Inc.

Application Date: 13.11.2020

The invention describes an autonomous farming system that incorporates a computing device to analyze plant data and detect growing deficiencies, prompting corrective actions through a farming controller. By utilizing machine learning models and sensor data, the system is able to autonomously optimize plant growth conditions, ultimately improving agricultural efficiency. This innovative technology falls within the realm of autonomous farming systems specifically designed to monitor and enhance plant growth in indoor settings. Compared to traditional farming methods, this system provides significant advantages by allowing for real-time monitoring and precise adjustments to plant conditions. As a result, it is able to boost crop yield, decrease the need for manual labor, optimize resource utilization and promote sustainable agricultural practices.

Figure 7.6 An autonomous indoor farming facility

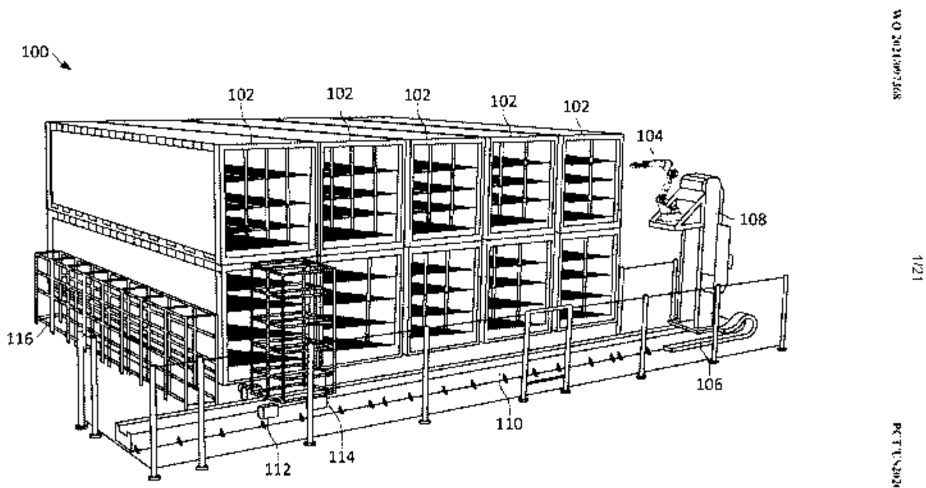
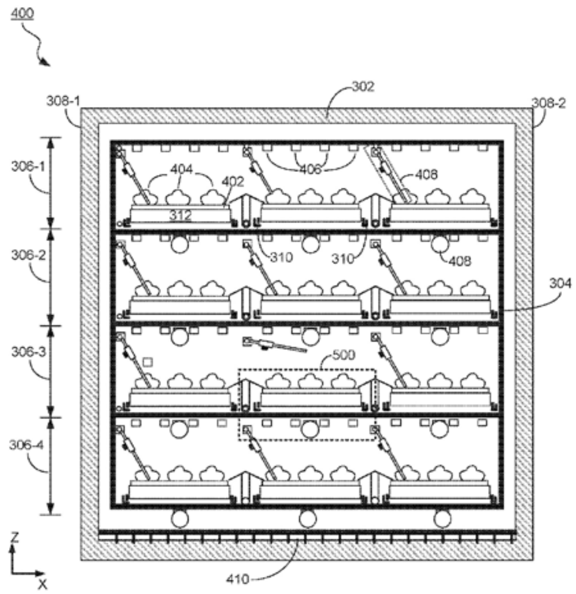


FIG. 1A

Source: WO2021/097368.

Figure 7.7 An indoor farming module



Source: WO2021/097368.

Figure 7.8 Flow chart showing an example method of autonomous farming

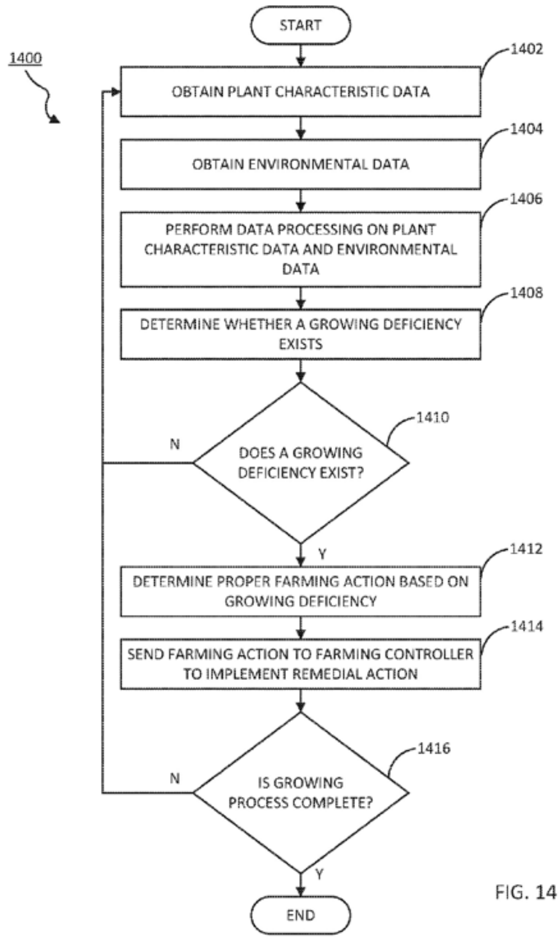


FIG. 14

Source: WO2021/097368.

Acronyms

AI	Artificial Intelligence
CAGR	Compound Annual Growth Rate
CREA	Council for Research in Agriculture (Italy)
EP	European Patent
EPO	European Patent Office
GHG	greenhouse gas
IoT	Internet of Things
IP	intellectual property
IPC	International Patent Classification
NASA	National Aeronautics and Space Administration
OECD	Organisation for Economic Co-operation and Development
PCT	Patent Cooperation Treaty
UPOV	International Union for the Protection of New Varieties of Plants
USDA	U.S. Department of Agriculture
USPTO	United States Patent and Trademark Office
WIPO	World Intellectual Property Organization

Glossary

Agrifood: the conjunction of AgriTech and FoodTech domains, both harnessing the power of data analytics, biotechnology and automation relating to the commercial production of food by farming.

AgriTech: involves the application of cutting-edge technologies such as drones, sensors and artificial intelligence (AI) to enhance crop yields, optimize water usage and improve soil health.

CAGR: compound annual growth rate; initially used to calculate and determine the rate of investment return, it represents the average annual growth rate between two dates in the study.

European patent (EP): a European patent can be obtained for all the European Patent Convention (EPC) locations by filing a single application at the European Patent Office (EPO). European patents granted by the EPO have the same legal rights and are subject to the same conditions as national patents (granted by the national patent office). A granted European patent is a "bundle" of national patents, which must be validated at the national patent office to be effective in member locations. The validation process could include submission of a translation of the specification, payment of fees and other formalities at the national patent office. Once a European patent is granted, competence is transferred to the national patent offices. Other regional patents or procedures also exist: the Eurasian patent (EA), ARIPO patent (AP) for English-speaking Africa and OAPI patent (OA) for French-speaking Africa.

FoodTech: focuses on developing new and innovative solutions for food production, processing and delivery, with a particular emphasis on sustainability, food safety and nutrition.

Geographic coverage: global patents within Questel Orbit Intelligence. Detailed information on the geographic coverage of Orbit Intelligence can be found in the solution home of Orbit Intelligence.[1]

Granted patent: once examined by the IP office, an application becomes a granted patent or is rejected. If granted, the patent gives his owner a temporary right for a limited time period (normally 20 years) to prevent unauthorized use of the technology outlined in the patent. Procedure for granting patents varies widely between locations according to national laws and international agreements. Note that in the same patent family, an application can be granted in one location and rejected in another.

International patent family: defined as a patent family that has been filed and published in two or more jurisdictions (sometimes also known as foreign-oriented patent families or extended patent families). This contrasts with a domestic-only patent family or a non-international patent family, which consists of patent family filed in only a single jurisdiction (often known as a "singleton").

1 See https://intelligence.help.questel.com/en/support/solutions/77000204065.

Patent applicant: when a person is applying for a patent, the word "applicant" refers to the assignee, the person to whom the inventor is under an obligation to assign the invention, or the person who otherwise shows sufficient proprietary interest in the matter.

Patent application: to obtain a patent, an application must be filed in the appropriate IP office with all the necessary documents and fees. The IP office will conduct an examination to decide whether to grant or reject the application. Patent applications are generally published 18 months after the earliest priority date of the application. Prior to that publication, the application remains confidential.

Patent classification: patent classification is a system for examiners of IP offices or other people to code documents, such as published patent applications, according to the technical features of their content. The International Patent Classification (IPC) is agreed internationally. The European Patent Office (EPO) and USPTO launched a joint project to create the Cooperative Patent Classification (CPC) in order to harmonize the patent classifications systems between the two offices.

Patent family: defined as an "invention-based family" using the Questel FAMPAT family grouping. The FAMPAT patent family definition from Questel incorporates the EPO's strict family rule (same priority application(s)) with additional rules (applications falling outside the 12 months filing limit; links between EPO and PCT publications…) etc. It is seen as a reasonable compromise between strict family and extended family (e.g. INPADOC) definitions.

PCT (WO): the Patent Cooperation Treaty (PCT) is an international patent law treaty concluded in 1970, administered by the World Intellectual Property Organization (WIPO), between more than 140 Paris Convention locations. The PCT makes it possible to seek patent protection for an invention simultaneously in each of a large number of locations by filing a single "international" patent application instead of filing several separate national or regional patent applications. The granting of patents remains under the control of the national or regional patent offices, which is referred to as the "national phase."

Priority filing: the first location in which a particular invention has a patent application filed, also known as the office of first filing.

Unicorn status: a startup company valued at over US$1 billion which is privately owned and not listed on a share market.

Appendices

Find out more about the methodology used, the technical definitions of each sub-domain, and the approach to searching Agrifood-related patents.

Appendix A. Geographical and temporal coverage

The Questel Orbit Intelligence database has worldwide geographical coverage. The Agrifood dataset covers patent families with an earliest priority date in the last 20 years (2004–2023). Most of the analysis in this report has been conducted using international patent families (a patent family that is filed and published in two or more jurisdictions). Due to the standard 18-month delay between earliest priority date and publication, and the additional delay for an international patent family to be formed (i.e. publication of the patent family in two or more jurisdictions), the dataset built in April 2024 wil be incomplete for 2022, 2023 and 2024.

Appendix B. Search query and dataset construction

B.1 AgriTech domain

Automation

Automation in agriculture refers to IT-related methods helping farmers to make data-driven decisions by providing real-time information on crop conditions, weather patterns and other factors that affect crop growth and yield.

On one hand it includes automated processes for precision in various farming processes, reducing dependency on manual labor and potential errors. Tasks such as planting, irrigation and harvesting are automated, allowing for precise execution and consistent results. This not only saves time but also enhances the accuracy of operations.

On the other hand, it also includes smart farming, which is built upon the foundation of interconnected devices and IoT sensors that synergize to usher in a transformational change in how farms are managed and operated.

S.No	Search string
1	((AGRICULTUR+ OR FARMING OR FARMED OR HORTICULTUR+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULT+) AND (ARTIFICIAL_INTELLIGENCE OR "AI" OR ((MACHINE OR DEEP) 2D LEARN+) OR NEURAL+_NETWORK+ OR ((NATURAL OR LARGE) D LANGUAGE? D (MODEL? OR PROCESS+ OR GENERAT+ OR UNDERSTAND+ OR PROGRAM+)) OR ((COMPUTER OR MACHINE) 2D VISION+) OR (MODEL OR ALGORITHM)))) /TI/AB/CLMS
2	(((CROP? OR CULTIVA+) AND (ARTIFICIAL_INTELLIGENCE OR "AI" OR ((MACHINE OR DEEP) 2D LEARN+) OR NEURAL+_NETWORK+ OR ((NATURAL OR LARGE) D LANGUAGE? D (MODEL? OR PROCESS+ OR GENERAT+ OR UNDERSTAND+ OR PROGRAM+)) OR ((COMPUTER OR MACHINE) 2D VISION+) OR (("NLP" OR "NLG" OR "NLU" OR "LLM" OR "CNN" OR "CCNN" OR "RNN" OR "RVNN") 2D (MODEL OR ALGORITHM)))) /TI/AB/CLMS AND (((HARVEST OR FARM+ OR AGRICULTUR+ OR HORTICULTUR+ OR ((CROP? OR CULTIVA+) P (PLANT? OR DISEASE? OR LAND))))/DESC OR (A01?)/IPC/CPC)) NOT ((A61? OR A01N OR A01P OR C12?)/IPC/CPC NOT (G06?)/IPC/CPC)
3	((AGRICULTUR+ OR FARMING OR FARMED OR HORTICULTUR+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULT+) P (AUTOMATI+ OR AUTOMATED) P (SYSTEM? OR PROCESS+ OR PLATFORM?))/TI/AB/CLMS
4	((CROP? OR CULTIVA+) P (AUTOMATI+ OR AUTOMATED) P (SYSTEM? OR PROCESS+ OR PLATFORM?))/TI/AB/CLMS AND (((CROP? OR CULTIVA+) P (HARVEST OR PLANT? OR FARM+ OR AGRICULTUR+ OR HORTICULTUR+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULTUR+ OR FRUIT? OR VEGETABLE? OR SEED? OR SEEDLING? OR FUNGI OR FUNGUS OR MUSHROOM?))/DESC OR (A01?)/IPC/CPC)
5	((AGRICULTUR+ OR FARMING OR FARMED OR HORTICULTUR+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULT+) P (AUTOMATI+ OR AUTOMATED) P (MACHINE+ OR EQUIPMENT? OR DEVICE OR APPARATUS))/TI/AB/CLMS
6	((CROP? OR CULTIVA+) P (AUTOMATI+ OR AUTOMATED) P (MACHINE+ OR EQUIPMENT? OR DEVICE OR APPARATUS))/TI/AB/CLMS AND (((CROP? OR CULTIVA+) P (HARVEST OR PLANT? OR FARM+ OR AGRICULTUR+ OR HORTICULTUR+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULTUR+ OR FRUIT? OR VEGETABLE? OR SEED? OR SEEDLING? OR FUNGI OR FUNGUS OR MUSHROOM?))/DESC OR (A01?)/IPC/CPC)
7	((AGRICULTUR+ OR FARMING OR FARMED OR HORTICULTUR+ OR CROP? OR CULTIVA+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULT+) P (SMART OR INTELLIGENT OR (REAL_TIME) OR IOT OR (INTERNET_OF_THINGS) OR MOBILE))/TI/AB/CLMS AND (A01?)/IPC/CPC
8	((AGRICULTUR+ OR FARMING OR FARMED OR HORTICULTUR+ OR CROP? OR CULTIVA+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULT+) P (SMART OR INTELLIGENT OR (REAL_TIME) OR IOT OR (INTERNET-OF-THINGS) OR MOBILE))/TI/AB/CLMS AND (G06Q OR G05D OR H04L OR G05B OR G06K OR G06F OR G06V)/IPC/CPC
9	1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8
10	9 AND EPD>2003
11	10 NOT NPN=1

Source: WIPO.

Carbon farming

Carbon farming (also known as carbon sequestration) is a system of agricultural management that helps the land store more carbon and reduce the amount of greenhouse gases that it releases into the atmosphere.

Sustainable forest management practices do similar good by minimizing greenhouse gases and accumulating carbon dioxide in wood. Tribal Nations can do this is a number of different ways. For example, Indian agriculture producers can manage their grazing lands to conserve and restore vegetation, including tree cover along waterways. This practice helps the land store carbon and remove greenhouse gases from the atmosphere, as well as provides benefits to nearby water sources. Landowners can also implement fertilizer reduction strategies, such as applying compost or biochar (charcoal used as a soil additive to improve crop yield), that reduce the amount of greenhouse gases tied up in vegetation. Healthy forests absorb and hold carbon dioxide emissions produced from other sources and are an important source of greenhouse gas (GHG) sequestration.

Carbon offsets can be created through a variety of strategies, including:

– avoided deforestation and permanent land conservation
– reforestation and replanting activities
– improved forest management and stewardship in working forests where harvesting occurs.

Improved forest management focuses on long-term, sustainable practices to ensure that forests continue to remove CO_2 from the atmosphere, since deforestation accounts for between 15 and 20 percent of the global increase in GHG levels. Activities include thinning out, selective harvest, regeneration and planting, and fertilization to enable productive and sustainable forest growth. Similar to forestry, native grasses and other vegetation provide a natural source of GHG absorption and sequestration. Carbon offsets from this category focus on maintaining native plant life through permanent land conservation and avoiding conversion for commercial development or intensive agriculture.

S.No	Search string
1	((CARBON OR CO2 OR GREENHOUSE_GAS??) 10D (FARMING OR SEQUEST+))/TI/AB/CLMS/OBJ
2	((((CARBON OR CARBON_DI_OXIDE OR CARBON_DIOXIDE OR CO2 OR GREENHOUSE_GAS??) 6D (FARMING OR SEQUEST+ OR STORAGE OR STORING OR STORED OR STORE OR UTILIZ+ OR UTILIS+ OR ACCUMULAT+ OR CAPTUR+))/TI/AB/CLMS/OBJ AND (AGRICULTUR+ OR PLANTATION? OR CROP? OR SOIL OR FOREST+ OR VEGETATION OR FARMLAND? OR WOOD OR ROOTS)/TI/AB/CLMS/DESC/ODES/OBJ) AND (Y02P+ OR B01D+ OR Y02C+ OR Y02E+)/IPC/CPC)
3	((((CARBON OR CARBON_DI_OXIDE OR CARBON_DIOXIDE OR CO2 OR GREENHOUSE_GAS??) 10D (FARMING OR SEQUEST+ OR STORAGE OR STORING OR STORED OR STORE OR UTILIZ+ OR UTILIS+ OR ACCUMULAT+ OR CAPTUR+))/TI/AB/CLMS/OBJ AND (AGRICULTUR+ OR PLANTATION? OR CROP? OR SOIL OR FOREST+ OR VEGETATION OR FARMLAND? OR WOOD OR ROOTS)/TI/AB/CLMS/OBJ))
4	((((REDUC+ OR MINIMI+ OR ELIMINAT+) P (CARBON OR CO2 OR GREENHOUSE_GAS??))/TI/AB/CLMS/OBJ AND (AGRICULTUR+ OR PLANTATION? OR CROP? OR SOIL OR FOREST+ OR VEGETATION OR LAND? OR FARMLAND? OR WOOD OR ROOT? OR LEAVES)/TI/AB/CLMS/DESC/ODES/OBJ) AND ((Y02P+ OR B01D+ OR Y02C+ OR Y02E+))/IPC/CPC)
5	1 OR 2 OR 3 OR 4
6	5 AND EPD>2003
7	6 NOT NPN=1

Source: WIPO.

Compliance/trackability

Compliance/trackability refers to the ability to trace and track products or processes within the agricultural supply chain to ensure they meet regulatory requirements and industry standards.

S.No	Search string
1	(AGRICULTUR+ OR FARMING OR FARMED OR HORTICULTUR+ OR CROP? OR CULTIVA+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULT+)/TI/ABS/CLMS/OBJ
2	(G09F-003+ or H04L-009+ or G06Q-030/018 or G06Q-030/001 or G06Q-030/012 or G06Q-030/014 or G06Q-030/015 or G06Q-030/016 or G06Q-010/08/7+ or G06F-021+ or G06Q-010/08/33 or A01K-011+ or G06Q-010/06/395 or A01G-009/00/6)/IPC/CPC
3	1 AND 2 AND EPD>2003
4	3 NOT NPN=1

Source: WIPO.

Connectivity/sensors/smart farming

Connectivity/sensors/smart farming is built upon the foundation of interconnected devices and IoT sensors that synergize to usher in a transformational change in how farms are managed and operated. Sensors can be used to:

- monitor mechanical and agricultural assets
- leverage data to improve crop yields
- improve sustainable resource management and environmental footprint
- track and contain disease/blight outbreaks
- reduce operating costs and per-unit costs
- decrease human exposure to pesticides and agrichemicals
- make more informed decisions during unforeseen events
- strengthen the supply chain by allowing true producer-to-consumer marketplaces.

S.No	Search string
1	((SENSOR OR SENSORS)/TI/AB/CLMS/OBJ AND (AGRICULTUR+ OR FARMING OR CULTIVA+ OR HORTICULTURE OR CROP? OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY)/TI/AB/CLMS/OBJ)
2	((IMPROV+ OR MONITOR+ OR FORECAST+ OR MANAG+ OR ANALYS+ ANALYZ+ OR DIAGNOS+ OR CONTROL+ OR ESTIMAT+ OR MINIMIZ+ OR PREDICT+ OR EXAMIN+ OR ELIMINAT+ OR STUDY+ STUDIES OR PROTECT+ OR INHIBIT+ OR REPEL+ OR COMBATING OR TREAT OR TREATING OR TREATED OR MITIGAT+) P (CLIMATE OR TERRAIN OR SOIL OR PEST? OR IRRIGATION OR FERTILIZER? OR NEMATODES OR DISEASE? OR FUNGAL OR BACTERIAL OR INFECTION? OR MOISTURE OR ABIOTIC OR BIOTIC OR IRRIGATION OR PESTICIDE? OR NEMATICIDE? OR EROSION OR POROSITY OR FUNGICIDE? OR TEMPERATURE OR WIND OR HARVEST+ OR TILLAGE OR SOWING OR MOISTURE OR HUMID OR HUMIDITY))/TI/AB/CLMS/OBJ AND (AGRICULTUR+ OR FARMING OR CULTIVA+ OR HORTICULTURE OR CROP? OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY)/TI/AB/CLMS/OBJ AND (SENSOR OR SENSORS)/TI/AB/CLMS/OBJ
3	(((IMPROV+ OR MONITOR+ OR FORECAST+ OR MANAG+ OR ANALYS+ ANALYZ+ OR DIAGNOS+ OR CONTROL+ OR ESTIMAT+ OR MINIMIZ+ OR PREDICT+ OR EXAMIN+ OR ELIMINAT+ OR STUDY+ STUDIES OR PROTECT+ OR INHIBIT+ OR REPEL+ OR COMBATING OR TREAT OR TREATING OR TREATED OR MITIGAT+) P (AGRICULTUR+ OR FARMING OR CULTIVA+ OR HORTICULTURE OR CROP? OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY)) P (SENSOR OR SENSORS))/TI/AB/CLMS/OBJ/DESC/ODES
4	((SENSOR OR SENSORS) P (CLIMATE OR TERRAIN OR SOIL OR PEST? OR IRRIGATION OR FERTILIZER? OR NEMATODES OR DISEASE? OR FUNGAL OR BACTERIAL OR INFECTION? OR MOISTURE OR ABIOTIC OR BIOTIC OR IRRIGATION OR PESTICIDE? OR NEMATICIDE? OR EROSION OR POROSITY OR FUNGICIDE? OR TEMPERATURE OR WIND OR HARVEST+ OR TILLAGE OR SOWING OR MOISTURE OR HUMID OR HUMIDITY))/TI/AB/CLMS/OBJ/DESC/ODES AND (AGRICULTUR+ OR FARMING OR CULTIVA+ OR HORTICULTURE OR CROP? OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY)/TI/AB/CLMS/OBJ/DESC/ODES
5	1 OR 2 OR 3 OR 4
6	5 AND EPD>2003
7	6 NOT NPN=1

Source: WIPO.

Crop adaptation and genetics

Crop adaptation and genetics supports the heightened production of nutritional food and the reduction of crop losses imposed by extreme events like droughts, high temperatures, floods, diseases and pests.

Induced genetic variation is important for crop improvement, especially in instances where there is limited variation in existing germplasm pools to achieve desired levels of crop performance, and where techniques such as hybridization cannot be easily applied. Its application becomes further significant as the dual threats of population growth and climate change increasingly challenge global food and nutrition security. Higher production of nutritional food and reduction of crop losses imposed by extreme events like droughts, high temperatures, floods, diseases and pests call for induced novel genetic variation.

While recent breakthroughs in whole genome-based mutation detection technologies increase the efficiency and precision of breeding in all crops, in vitro techniques coupled with mutagenesis broaden the genetic base of vegetative and horticultural tree crops and reduce their breeding cycles.

S.No	Search string
1	(A01H-001+ OR A01H-003+ OR A01H-004 OR Y02A-040+)/IPC/CPC
2	((AGRICULTUR+ OR CROP? OR GRAIN? OR FARMLAND OR FARMING OR PLANT? OR CULTIVA+ OR HORTICULTURE OR FRUIT? OR VEGETABLE?)/TI/AB/CLMS/OBJ AND (C12N-015+)/IPC/CPC)
3	((AGRICULTUR+ OR CROP? OR GRAIN? OR FARMLAND OR FARMING OR PLANT? OR CULTIVA+ OR HORTICULTURE OR FRUIT? OR VEGETABLE?)/TI/AB/CLMS/OBJ AND (C12Q-25+ OR C12Q-2600/13+)/IPC/CPC)
4	(AGRICULTUR+ OR CROP? OR GRAIN? OR FARMLAND OR FARMING OR PLANT? OR CULTIVA+ OR HORTICULTURE OR FRUIT? OR VEGETABLE?)/TI/AB/CLMS/OBJ AND (Y02A-090/10)/IPC/CPC
5	(((BREEDING OR MUTAGENESIS OR MUTATION? OR MUTANT+ OR DELET+? OR SUBSTITUT+? OR INVERSION? OR POLYMORPHISM? OR EXPRESSION) 6D (GENE? OR NUCLEIC_ACID OR NUCLEOTIDE? OR PROTEIN? OR PEPTIDE? OR ALLELE?))/TI/AB/CLMS/OBJ AND (AGRICULTUR+ OR CROP? OR GRAIN? OR FARMLAND OR FARMING OR PLANT? OR CULTIVA+ OR HORTICULTURE OR FRUIT? OR VEGETABLE?)/TI/AB/CLMS/OBJ)
6	(((BREEDING OR MUTAGENESIS OR MUTATION? OR MUTANT+ OR DELET+? OR SUBSTITUT+? OR INVERSION? OR POLYMORPHISM? OR EXPRESSION) 6D (GENE? OR NUCLEIC_ACID OR NUCLEOTIDE? OR POLYNUCLEOTIDE? OR PROTEIN? OR PEPTIDE? OR ALLELE?))/TI/AB/CLMS/DESC/ODES/OBJ AND (AGRICULTUR+ OR CROP? OR GRAIN? OR FARMLAND OR FARMING OR PLANT? OR CULTIVA+ OR HORTICULTURE OR FRUIT? OR VEGETABLE?)/TI/AB/CLMS/OBJ)
7	1 OR 2 OR 3 OR 4 OR 5 OR 6
8	7 AND EPD>2003
9	8 NOT NPN=1

Source: WIPO.

Planting/harvesting/storage

The Planting/harvesting/storage segment relates to agricultural processes and machineries dedicated to crop management.

S.No	Search string
1	(A01B/IPC/CPC NOT ((ROBOT OR DRONE?)/TI/AB/CLMS OR ((AUTO+ 1W STEER+) OR (PESTICIDE NOT FERTILI+))/TI/AB/CLMS)) AND (HARVEST+ OR PLANTING OR STORAG+)/TI/AB/CLMS
2	(A01C-001 OR A01C-007 OR A01C-009 OR A01C-011 OR A01C-014 OR A01F)/IPC/CPC
3	A01C-005/IPC/CPC NOT (MANUR+ OR FERTILI+)/TI/AB/CLMS
4	(A01C-017 OR A01C-019)/IPC/CPC AND ((SEED+ OR PLANTING OR PLANTER+) NOT FERTILI+)/TI/AB/CLMS
5	A01D/IPC/CPC NOT (LAWN S MOW+)/TI/AB/CLMS
6	((((STORAGE OR STORING) S (((AGRI+ OR HORTICULTUR+) 2D (PRODUCE OR HARVEST+)) OR FRUIT? OR CEREAL? OR VEGETABLE+ OR MUSHROOM?)) NOT (MANUR+ OR FERTILI+ OR WINE OR SUGAR))/TI/AB/CLMS) NOT A23B/IPC/CPC
7	(1:6) AND EPD>2003
8	7 NOT NPN=1

Source: WIPO.

Education and training

Education and training is the instruction, teaching and training surrounding agriculture as well as the management of land and natural resources.

Agricultural education teaches students and aspiring farmers about farming, food production, plant sciences, biology, animal care, sustainable use of natural resources, and more. It will typically also include training in leadership, farm safety and agribusiness leadership. It may be available for K-12 students, college and graduate students, working farmers and other agribusiness professionals.

S.No	Search string
1	((EDUCATION+ OR EDUCATING OR EDUCATE? OR TEACHING OR TUTORING OR TUTORIAL? OR ((ONLINE OR DISTANCE OR DISTANT OR PRACTICAL) 4D (TRAINING OR LEARNING)))/TI/AB/CLMS/OBJ AND (AGRITECH+ OR AGRICULTUR+ OR CROP? OR FARMLAND OR FARMING OR HORTICULTURE OR HUSBANDRY OR LIVESTOCK? OR POULTR+))/TI/AB/CLMS/OBJ
2	((EDUCATION+ OR EDUCATING OR EDUCATE? OR TEACHING OR TUTORING OR TUTORIAL? OR ((ONLINE OR DISTANCE OR DISTANT OR PRACTICAL) 4D (TRAINING OR LEARNING))) 10D (AGRITECH+ OR AGRICULTUR+ OR CROP? OR FARMLAND OR FARMING OR HORTICULTURE OR HUSBANDRY OR LIVESTOCK? OR POULTR+))/TI/AB/CLMS/OBJ/DESC/ODES
3	((AGRITECH+ OR AGRICULTUR+ OR CROP? OR FARMLAND OR FARMING OR HORTICULTURE OR HUSBANDRY OR LIVESTOCK? OR POULTR+)/TI/AB/CLMS/DESC/ODES/OBJ AND (G06Q-050/20)/IPC/CPC)
4	(1 OR 2 OR 3) AND EPD>2003
5	4 NOT NPN=1

Source: WIPO.

Economic management/whole farm management software

Economic management/whole farm management software is designed to automate various farm activities, including record management, data storage, monitoring and analyzing farming activities. It also helps in streamlining production and work schedules.

Each farm has specific requirements, which is why the software is customized to meet individual needs. Farming is a specialized activity, so it is crucial to choose the right software for your farm. It is essential to forecast and measure profits, as farming is now considered a serious business. Keeping track of expenses and farm activities is important for efficiency and productivity.

Farm management software includes features to track financial activities and improve overall management. In addition, the software allows farmers to develop crop plans by providing a comprehensive view of the farm. By collecting, analyzing and generating reports, farmers can make informed decisions on crop rotation, pest control methods and fertilizer applications.

The software also helps in tracking and measuring field activities by assisting farm employees in keeping relevant information for farm managers to oversee. It enables farmers to track yields and identify successful crops for better planning throughout different seasons. Moreover, the software helps in managing risk portfolios by studying past field performance to make informed investment decisions. It also helps in understanding input costs, projected yields and sale prices.

Modern farmers face external risks such as erratic weather conditions, diseases, pests and unpredictable market demands. An effective farm management software alerts farmers to potential risks and helps them make decisions on how to address these challenges.

S.No	Search string
1	(AGRICULTUR+ OR FARMING OR FARMED OR HORTICULTUR+ OR CROP? OR CULTIVA+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULT+)/TI/ABS/CLMS/OBJ
2	(G06Q-050/02 OR G06Q-010+)/IPC/CPC
3	1 AND 2 AND EPD>2003
4	3 NOT NPN=1

Source: WIPO.

Investment/exchange platform

Investment/exchange platform is a type of financial service that provides opportunities for investors to support sustainable farming practices, agribusinesses or agricultural technologies. Investors can typically browse through different projects, select ones that align with their investment goals, and contribute funds towards the development and growth of the chosen projects.

S.No	Search string
1	((AGRICULTUR+ OR FARMING OR FARMED OR HORTICULTUR+ OR CROP? OR CULTIVA+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULT+))/TI/AB/CLMS AND (G06Q-040)/IPC/CPC
2	1 AND EPD>2003
3	2 NOT NPN=1

Source: WIPO.

Livestock management

Livestock management involves the management of farm animals and supervision of farm workers. Livestock management is a complex and multifaceted task that requires a deep understanding of animal science, animal husbandry and sound business practices. In addition to these skills, many livestock managers are also responsible for maintaining detailed financial records for their operations.

Depending on the size of the farm, managers may also be involved in physical tasks such as operating machinery and tending to the livestock directly. Successful dairy farms, cattle ranches, swine operations and poultry farms all rely on effective livestock management to thrive and turn a profit. Livestock managers must consider a wide range of factors when caring for their herds, including animal health, nutrition, reproduction, grazing, hay and forage management, fencing and more.

Staying abreast of market requirements and fluctuations is crucial, as it impacts the optimal times to market livestock. Adhering to industry best practices helps managers make informed decisions about the care techniques that will yield the best results for their livestock. For instance, the demand for grass-fed beef is on the rise, outpacing the demand for grain-fed beef.

Many livestock managers utilize specialized agricultural software to streamline their operations and keep detailed records of all activities related to their livestock, such as feeding, tagging, breeding and treatments. This software also helps with scheduling and budgeting, providing valuable information to farm staff, animal nutritionists and veterinarians. Ear tagging allows for individual tracking of each animal, particularly in larger operations involving cattle, swine and sheep.

In light of increasing concerns about the sustainability and ethical treatment of animals in livestock operations, managers are facing mounting pressure to adopt more sustainable and humane practices. While livestock production is a vital source of livelihood for millions of farmers worldwide, consumers are becoming more conscious of the greenhouse gas emissions associated with livestock and are demanding more humanely raised, free-range meats and eggs over products from intensive factory farming operations.

S.No	Search string
1	(LIVESTOCK 8D (MANAGEMENT OR FARMING))/TI/AB/CLMS/DESC/ODES/OBJ
2	((LIVESTOCK) P (DRONE? OR ROBOT+ OR AERIAL_VEHICLE? OR SENSOR? OR IMAG+ OR SATELLITE))/TI/AB/CLMS/DESC/ODES/OBJ
3	(A01K+ OR A61D-017+ OR A61D-019+ OR A01J-001+ OR A01J-003+ OR A01J-005+ OR A01J-007+ OR A01J-009+)/IPC/CPC
4	((HUSBANDRY OR POULTRY) P (DRONE? OR ROBOT+ OR AERIAL_VEHICLE? OR SENSOR? OR IMAG+ OR SATELLITE))/TI/AB/CLMS/DESC/ODES/OBJ
5	((HUSBANDRY OR POULTRY) 8D (MANAGEMENT OR FARMING))/TI/AB/CLMS/DESC/ODES/OBJ
6	(Y02P-060/50 OR Y02P-060/60 OR Y02A-040/70 OR Y02A-040/80 OR Y02A-040/81)/IPC/CPC
7	(LIVESTOCK OR HUSBANDRY OR POULTRY)/TI/AB/CLMS/OBJ
8	1:7
9	8 AND EPD>2003
10	9 NOT NPN=1

Source: WIPO.

Mapping/imagery

Mapping/imagery services refer to the use of aerial or satellite imagery to gather data and create detailed maps of agricultural fields. These maps can provide valuable information about the health, size and composition of crops, as well as identify areas of stress or disease. By analyzing this data, farmers can make more informed decisions about irrigation, fertilization and pest control, ultimately leading to improved crop yields and more sustainable farming practices.

S.No	Search string
1	((AGRICULTUR+ OR FARMING OR CULTIVA+ OR HORTICULTURE OR CROP? OR FARMLAND OR FARM? OR HUSBANDRY OR LIVESTOCK? OR POULTRY)/TI/AB/CLMS/OBJ/DESC/ODES AND (G06T+ OR G06V+ OR G06Q-050/02 OR H04N+)/IPC/CPC)
2	((AGRICULTUR+ OR FARMING OR CULTIVA+ OR HORTICULTURE OR CROP? OR FARMLAND OR FARM? OR HUSBANDRY OR LIVESTOCK? OR POULTRY) P (MAP? OR MAPPING OR IMAGE? OR IMAGERY OR IMAGING))/TI/AB/CLMS/OBJ
3	((AGRICULTUR+ OR FARMING OR CULTIVA+ OR HORTICULTURE OR CROP? OR FARMLAND OR FARM? OR HUSBANDRY OR LIVESTOCK? OR POULTRY)/TI/AB/CLMS/OBJ/DESC/ODES AND (G01C-021+ OR G01S-017+ OR G01S-019+ OR H04W-004+)/IPC/CPC)
4	((GEOSPATIAL)/TI/AB/CLMS/DESC/ODES/OBJ AND (AGRICULTUR+ OR FARMING OR CULTIVA+ OR HORTICULTURE OR CROP? OR FARMLAND OR FARM? OR HUSBANDRY OR LIVESTOCK? OR POULTRY)/TI/AB/CLMS/DESC/ODES/OBJ)
5	(AGRICULTUR+ OR FARMING OR CULTIVA+ OR HORTICULTURE OR CROP? OR FARMLAND OR FARM? OR HUSBANDRY OR LIVESTOCK? OR POULTRY)/TI/AB/CLMS/DESC/ODES/OBJ AND ((SATELLITE?) P (MAP? OR MAPPING OR IMAGE? OR IMAGERY OR IMAGING))/TI/AB/CLMS/DESC/ODES/OBJ
6	(AGRICULTUR+ OR FARMING OR CULTIVA+ OR HORTICULTURE OR CROP? OR FARMLAND OR FARM? OR HUSBANDRY OR LIVESTOCK? OR POULTRY) P (SATELLITE? OR GLOBAL_POSITION+_SYSTEM? OR GEOGRAPHIC_INFORMATION_SYSTEM?)/TI/AB/CLMS/DESC/ODES/OBJ
7	1:6 AND EPD>2003
8	7 NOT NPN=1

Source: WIPO.

Pest/disease management

Pest/disease management through chemical pesticides, and biocontrol methods: this supports environmentally friendly approaches involving the introduction of natural enemies, such as predators, parasites or pathogens, to control the population of harmful organisms.

S.No	Search string
1	(A01N-025+ OR A01N-027+ OR A01N-029+ OR A01N-031+ OR A01N-033+ OR A01N-035+ OR A01N-037+ OR A01N-039+ OR A01N-041+ OR A01N-043+ OR A01N-045+ OR A01N-047+ OR A01N-049+ OR A01N-051+ OR A01N-053+ OR A01N-055+ OR A01N-057+ OR A01N-059+ OR A01N-061+ OR A01N-063+ OR A01N-065+ OR A01P+ OR A01N2300/00)/IPC/CPC
2	((((PROTECT+ OR CONTROL+ OR INHIBIT+ OR REPEL+ OR MANAG+ OR ELIMINAT+ OR COMBATING OR TREAT OR TREATING OR TREATED OR MITIGAT+) 5D (DISEASE? OR PATHOGEN?? OR PEST? OR STRAIN? OR BACTERIA+ OR MICROBE? OR BACTERIUM OR MICRO?RGANISM? OR BACILL+ OR MICROBIOME? OR FUNGUS OR FUNGI OR MICROBIAL OR FUNGAL OR OOMYCOTA? OR NEMATODE? OR PARASITE? OR INSECT? OR INFECTION? OR VIRUS+)) AND (AGRICULTUR+ OR CROP? OR GRAIN? OR FARMLAND OR FARMING OR PLANT? OR CULTIVA+ OR HORTICULTURE OR FRUIT? OR VEGETABLE?))/TI/AB/CLMS)
3	((((PROTECT+ OR CONTROL+ OR INHIBIT+ OR REPEL+ OR MANAG+ OR ELIMINAT+ OR COMBATING OR TREAT OR TREATING OR TREATED OR MITIGAT+) 6D (DISEASE? OR PATHOGEN?? OR PEST? OR STRAIN? OR BACTERIA+ OR MICROBE? OR BACTERIUM OR MICRO?RGANISM? OR BACILL+ OR MICROBIOME? OR FUNGUS OR FUNGI OR MICROBIAL OR FUNGAL OR OOMYCOTA? OR NEMATODE? OR PARASITE? OR INSECT? OR INFECTION? OR VIRUS+)) 15D (AGRICULTUR+ OR CROP? OR GRAIN? OR FARMLAND OR FARMING OR PLANT? OR CULTIVA+ OR HORTICULTURE OR FRUIT? OR VEGETABLE?))/TI/AB/CLMS/OBJ/DESC/ODES)
4	(BIOCONTROL+ OR BIO_CONTROL+ OR (BIOLOGICAL+ 3D CONTROL+))/TI/AB/CLMS/OBJ
5	((((MONITOR+ OR FORECAST+ OR MANAG+ OR ANALYS+ ANALYZ+ OR DIAGNOS+ OR ESTIMAT+ OR PREDICT+ OR EXAMIN+ OR RESIST+) 5D (DISEASE? OR PATHOGEN?? OR PEST? OR STRAIN? OR BACTERIA+ OR MICROBE? OR BACTERIUM OR MICRO?RGANISM? OR BACILL+ OR MICROBIOME? OR FUNGUS OR FUNGI OR MICROBIAL OR FUNGAL OR OOMYCOTA? OR NEMATODE? OR PARASITE? OR INSECT? OR INFECTION? OR VIRUS+)) AND (AGRICULTUR+ OR CROP? OR GRAIN? OR FARMLAND OR FARMING OR PLANT? OR CULTIVA+ OR HORTICULTURE OR FRUIT? OR VEGETABLE?))/TI/AB/CLMS/OBJ)
6	((((MONITOR+ OR FORECAST+ OR MANAG+ OR ANALYS+ ANALYZ+ OR DIAGNOS+ OR ESTIMAT+ OR PREDICT+ OR EXAMIN+ OR RESIST+) 6D (DISEASE? OR PATHOGEN?? OR PEST? OR STRAIN? OR BACTERIA+ OR MICROBE? OR BACTERIUM OR MICRO?RGANISM? OR BACILL+ OR MICROBIOME? OR FUNGUS OR FUNGI OR MICROBIAL OR FUNGAL OR OOMYCOTA? OR NEMATODE? OR PARASITE? OR INSECT? OR INFECTION? OR VIRUS+)) 15D (AGRICULTUR+ OR CROP? OR GRAIN? OR FARMLAND OR FARMING OR PLANT? OR CULTIVA+ OR HORTICULTURE OR FRUIT? OR VEGETABLE?))/TI/AB/CLMS/OBJ/DESC/ODES)
7	1 OR 2 OR 3 OR 4 OR 5 OR 6
8	7 AND EPD>2003
9	8 NOT NPN=1

Source: WIPO.

Precision agriculture

Precision agriculture encompasses auto steer, wireless telematics, variable rate technology, indoor agriculture, remote sensing and data collection as well as predictive yield analytics and monitoring.

S.No	Search string
1	(((AGRICULTUR+ OR FARMING OR CULTIVA+ OR HORTICULTURE OR CROP? OR FARMLAND OR FARM? OR HUSBANDRY OR LIVESTOCK? OR POULTRY))/TI/AB/CLMS/DESC/ODES/OBJ AND ((SATELLITE? OR GLOBAL_POSITIONING_SYSTEM? OR GEOGRAPHIC_INFORMATION_SYSTEM?))/TI/AB/CLMS/DESC/ODES/OBJ)
2	(A01B-079/00/5 OR A01B-069/00 OR A01C-021/00)/IPC/CPC
3	(1 OR 2) AND EPD>2003
4	3 NOT NPN=1

Source: WIPO.

Robotics and drones

Robotics and drones automate slow, repetitive and dull tasks for farmers, allowing them to focus more on improving overall production yields. Robots are widely utilized in agriculture for various tasks such as harvesting and picking, weed control, autonomous mowing, pruning, seeding, spraying, thinning, phenotyping, sorting, packing and utility platforms.

Among these tasks, harvesting and picking stand out as one of the most common robotic applications in agriculture. This is primarily because robots can achieve high levels of accuracy and speed, leading to improved yield sizes and reduced crop waste left in the field.

Harvesting and picking robots play a crucial role in enhancing efficiency and productivity in the agricultural sector.

S.No	Search string
1	((ROBOT+ OR DRONE? OR AERIAL_VEHICLE?)/TI/AB/CLMS/OBJ AND (AGRICULTUR+ OR CROP? OR GRAIN? OR FARMLAND OR FARMING OR CULTIVA+ OR HORTICULTURE OR FRUIT? OR VEGETABLE?)/TI/AB/CLMS/DESC/ODES/OBJ)
2	(((IMPROV+ OR MONITOR+ OR FORECAST+ OR MANAG+ OR ANALYS+ ANALYZ+ OR DIAGNOS+ OR CONTROL+ OR ESTIMAT+ OR MINIMIZ+ OR PREDICT+ OR EXAMIN+ OR ELIMINAT+ OR STUDY+ STUDIES OR PROTECT+ OR INHIBIT+ OR REPEL+ OR COMBATING OR TREAT OR TREATING OR TREATED OR MITIGAT+) P (CLIMATE OR TERRAIN OR SOIL OR PEST? OR IRRIGATION OR FERTILIZER? OR NEMATODES OR DISEASE? OR FUNGAL OR BACTERIAL OR INFECTION? OR MOISTURE OR ABIOTIC OR BIOTIC OR IRRIGATION OR PESTICIDE? OR NEMATICIDE? OR EROSION OR POROSITY OR FUNGICIDE? OR TEMPERATURE OR WIND OR HARVEST+ OR TILLAGE OR SOWING OR MOISTURE OR HUMID OR HUMIDITY))/TI/AB/CLMS/OBJ AND (AGRICULTUR+ OR CROP? OR GRAIN? OR FARMLAND OR FARMING OR CULTIVA+ OR HORTICULTURE OR FRUIT? OR VEGETABLE? OR PLANT?)/TI/AB/CLMS/OBJ AND (ROBOT+ OR DRONE? OR AERIAL_VEHICLE?)/TI/AB/CLMS/OBJ)
3	(((IMPROV+ OR MONITOR+ OR FORECAST+ OR MANAG+ OR ANALYS+ ANALYZ+ OR DIAGNOS+ OR CONTROL+ OR ESTIMAT+ OR MINIMIZ+ OR PREDICT+ OR EXAMIN+ OR ELIMINAT+ OR STUDY+ STUDIES OR PROTECT+ OR INHIBIT+ OR REPEL+ OR COMBATING OR TREAT OR TREATING OR TREATED OR MITIGAT+) P (AGRICULTUR+ OR CROP? OR GRAIN? OR FARMLAND OR FARMING OR CULTIVA+ OR HORTICULTURE OR FRUIT? OR VEGETABLE?)) P (ROBOT+ OR DRONE? OR AERIAL_VEHICLE?))/TI/AB/CLMS/OBJ/DESC/ODES
4	((ROBOT+ OR DRONE? OR AERIAL_VEHICLE?) P (CLIMATE OR TERRAIN OR SOIL OR PEST? OR IRRIGATION OR FERTILIZER? OR NEMATODES OR DISEASE? OR FUNGAL OR BACTERIAL OR INFECTION? OR MOISTURE OR ABIOTIC OR BIOTIC OR IRRIGATION OR PESTICIDE? OR NEMATICIDE? OR EROSION OR POROSITY OR FUNGICIDE? OR TEMPERATURE OR WIND OR HARVEST+ OR TILLAGE OR SOWING OR MOISTURE OR HUMID OR HUMIDITY))/TI/AB/CLMS/OBJ/DESC/ODES AND (AGRICULTUR+ OR CROP? OR GRAIN? OR FARMLAND OR FARMING OR CULTIVA+ OR HORTICULTURE OR FRUIT? OR VEGETABLE? OR PLANT?)/TI/AB/CLMS/OBJ/DESC/ODES
5	1 OR 2 OR 3 OR 4
6	5 AND EPD>2003
7	6 NOT NPN=1

Source: WIPO.

Soil and fertilizer management

Soil and fertilizer management refers to solutions improving the health and fertility of soil, including crop rotation, cover cropping, organic fertilizers, with minimized use of chemical fertilizers and pesticides.

S.No	Search string
1	A01B/IPC/CPC NOT ((ROBOT OR DRONE?)/TI/AB/CLMS OR ((AUTO+ 1W STEER+) OR (PESTICIDE NOT FERTILI+) OR HARVEST+)/TI OR (A01G-013 OR A01N OR A01P)/IPC/CPC)
2	(A01C-003 OR A01C-005 OR A01C-013 OR A01C-015 OR A01C-021 OR A01C-023 OR A01G-011)/IPC/CPC
3	(A01C-017 OR A01C-019)/IPC/CPC NOT (SEED+ NOT FERTILI+)/TI/AB/CLMS
4	C05#/IPC/CPC
5	(B09C OR C09K-017 OR C09K-101 OR C09K-105 OR C09K-107 OR C09K-109)/IPC/CPC AND (SOIL OR FARMLAND OR FIELD)/TI/AB/CLMS
6	A01G-029/IPC/CPC AND FERTILI+/TI/AB/CLMS
7	(1:6) AND EPD>2003
8	7 NOT NPN=1

Source: WIPO.

Waste management

Waste management refers to solutions that minimize negative environmental impacts and promote resource conservation. It includes composting and recycling of crop residues, animal manure and agricultural chemicals.

S.No	Search string
1	((MANAGING OR MANAGE+ OR RECYCL+ OR UPCYCL+ OR COMPOST+ OR CONVERS+ OR CONVERT+ OR DISCARD+ OR UNWANTED OR EXCESS+ OR REPURPOS+ OR RECLAIM+) 5D (((AGRICULTUR+ OR FARMING OR FARMED OR HORTICULTUR+ OR CROP? OR CULTIVA+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR ANIMAL OR POULTRY OR AQUACULT+) 2D (MANURE OR FECES OR URINE OR DUNG OR EXCREMENT? OR BEDDING? OR FEATHER? OR DROPPING? OR FEED)) OR GRAINS OR FORAGE? OR STALK? OR STRAW OR HUSK? OR PLANT_DEBRIS OR GRASS_CLIPPING? OR BAGASSE OR MOLASSE? OR PEEL?))/TI/AB/CLMS OR (((RECYCL+ OR UPCYCL+ OR COMPOST+ OR DISCARD+ OR REPURPOS+) 5D (LEAVE? OR LEAF OR BRANCHE? OR PRUNING? OR TRIMMING?)) OR ((CONVERS+ OR CONVERT+) 2D (LEAVE? OR LEAF OR BRANCHE? OR PRUNING? OR TRIMMING?) 2D (WASTE OR REFUSE OR OFFAL OR BY_PRODUCT?)))/TI/AB/CLMS
2	((MANAGING OR MANAGE+ OR RECYCL+ OR UPCYCL+ OR COMPOST+ OR CONVERS+ OR CONVERT+ OR COLLECT+ OR STORAGE OR TRANSPORT+) P (((AGRICULTUR+ OR FARMING OR FARMED OR HORTICULTUR+ OR CROP? OR CULTIVA+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR ANIMAL OR POULTRY OR AQUACULT+) 5D (WASTE OR REFUSE OR OFFAL OR BYPRODUCT?))))/TI/AB/CLMS/OBJ/ADB
3	(((AGRICULTUR+ OR FARMING OR FARMED OR HORTICULTUR+ OR CROP? OR CULTIVA+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULT+) 2D (WASTE OR REFUSE OR OFFAL OR BY_PRODUCT?)))/TI/AB/CLMS
4	(((DISCARD+ OR DISPOS+ OR RECYCL+ OR UPCYCL+ OR CONVERS+ OR CONVERT+ OR REPURPOS+ OR REGENERAT+) 5D (PLASTIC? OR CARDBOARD OR CONTAINER? OR BOTTEL? OR FILM? OR OIL OR GREASE OR PACKAGING OR EQUIPMENT?) 5D (WASTE OR REFUSE OR OFFAL OR GARBAGE OR TRASH)) P (AGRICULTUR+ OR FARMING OR FARMED OR HORTICULTUR+ OR CROP? OR CULTIVA+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULT+ OR PESTICIDE? OR AGRO_CHEMICAL? OR SILAGE? OR INORGANIC+ OR HERBICIDE? OR FERTILIZER?)) /TI/AB/CLMS
5	(Y02W-030/40)/IPC/CPC AND (AGRICULTUR+ OR FARMING OR FARMED OR HORTICULTUR+ OR CROP? OR CULTIVA+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR ANIMAL OR POULTRY OR AQUACULT+)/TI/AB/CLMS
6	(Y02W-030/74)/IPC/CPC
7	(C05?)/IPC/CPC AND ((AGRICULTUR+ OR FARMING OR FARMED OR HORTICULTUR+ OR CULTIVA+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR ANIMAL OR POULTRY OR AQUACULT+) 2D (WASTE OR REFUSE OR OFFAL OR GARBAGE OR TRASH OR MANURE? OR FECES OR URINE OR DUNG OR EXCREMENT? OR BEDDING? OR FEATHER? OR DROPPING?)) /TI/AB/CLMS
8	1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7
9	8 AND EPD>2003
10	9 NOT NPN=1

Source: WIPO.

Water management

Water management embodies installations for producing fresh water, the treatment of water, wastewater, sewage or sludge, but also technics to improve land water use or availability as well as to control erosion.

S.No	Search string
1	((AGRICULTUR+ OR FARMING OR CULTIVA+ OR HORTICULTURE OR CROP? OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY) P (WATER OR IRRIGAT+OR DRINK+))/TI/AB/CLMS/DESC/ODES/OBJ AND (Y02A10-30 OR Y02A20+ OR C02F+ OR B63J1+ OR B63J4+ OR Y02A40-22)/IPC/CPC
2	((AGRICULTUR+ OR FARMING OR CULTIVA+ OR HORTICULTURE OR CROP? OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY) P ((+WATER OR IRRIGAT+ OR RAIN+ OR PRECIPIT+ OR AQUA OR "H2O") 3D (CONTROL+ OR BIO_CONTROL+ OR MONITOR+ OR FORECAST+ OR MANAG+ OR ANALYS+ ANALYZ+ OR DIAGNOS+ OR ESTIMAT+ OR PREDICT+ OR EXAMIN+ OR RESIST+ OR DRAIN+ OR QUALITY OR REDUC+ OR SCARCE OR FERTIGATION OR RE?USE+ OR SUSTAIN+)))/TI/AB/CLMS/DESC/ODES/OBJ
3	((AGRICULTUR+ OR FARMING OR CULTIVA+ OR HORTICULTURE OR CROP? OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY) P (DROUGHT OR (CLIMAT 3D CHANG+) OR ((IRRIGAT+ OR WATER OR DRAIN+) 6D (PRECISION OR SMART))))/TI/AB/CLMS/DESC/ODES/OBJ
4	(PRODUCT+ OR BIOPRODUCT+ OR MANUFACT+ OR BIOMANUFACT+ OR ((EXPRESSION OR PRODUCTION) D SYSTEM?) OR (((THERAPEUTIC PROTEIN?) OR (INTEREST)) 3D PRODUC+) OR ((RECOMBINANT+) D (PROTEIN? OR PRODUC+ OR VACCINE?)) OR ((POLY_PEPTIDE? OR PEPTIDE? OR (TARGET D GENE?) OR VIRUS OR +PHARMACEUTIC+ OR ENZYME? OR ANTIBOD+ OR HOMON? OR +SACCHARIDE? OR DNA? OR ? RNA? OR +NUCLEIC_ACID? OR NACRE?) 5D (PREPAR+ OR PRODUC+ OR EXPRESS+ OR +SYNTH#+)) OR ((GROWTH OR DEVELOP+ OR PHYSIOLOG+ OR METABOLISM? OR PATHOLOG+ OR +CLINICAL OR PHARMACOLOG+ OR IMMUNITY OR TOXICITY) 5D (STUD+ OR MODEL? OR RESEARCH)) OR (DRUG D (SCREEN+ OR DISCOVER+)) OR (IN_VITRO D SCREEN+))/TI/AB/CLMS
5	1 OR 2 OR 3
6	5 NOT 4
7	6 AND EPD>2003
8	7 NOT NPN=1

Source: WIPO.

B.2 FoodTech domain

Consumer technology

Consumer technology includes kitchen equipment for personal use, and services, apps and devices that help users identify and access the best foods, along with providing background information such as recipes, nutrigenomics and food discovery.

S.No	Search string
1	((RETAIL OR E_COMMERCE OR (ELECTRONIC+ D COMMERCE) OR TRANSACTION OR TRADING OR (ONLINE D SHOP+) OR (SALES PLATFORM?) OR (BUY NOW PAY LATER) OR BNPL OR (DIGITAL WALLET?) OR ((DIGITAL OR MOBILE OR CASHIER_LESS) D (PAYMENT? OR PURCHASE)) OR ((CASHIER_LESS OR AUTOMATED OR SELF_SCANNING OR SELF_SERVICE) D (CHECKOUT? OR PURCHASE OR SALE? OR PAYMENT?)) OR (SMART W CART?) OR (JUST_WALK_OUT) OR ((COMMERCE OR PAYMENT? OR PURCHASE OR SALE?) D (APPLICATION? OR APP))) F ((FOOD? OR FOODSTUFF? OR BEVERAGE? OR FOOD_TECH+ OR MEAL? OR CATERING OR FRUIT? OR VEGETABLE? OR MEAT? OR TAKEAWAY OR PERISHABLE? OR VICTUAL? OR EDIBLE? OR EATABLE? OR DRINK? OR ((AGRICULTUR+ OR AQUATIC) W PRODUCT?) OR CROP?)))/TI/AB/CLMS AND (G06Q-030 OR G06Q-010/08?? OR G06Q-010/02 OR G06Q-010/04 OR G06Q-020 OR G06Q-050 OR G06F OR G07F OR G07G OR B62B OR B65D OR B67D OR G06V OR G05B OR H04N OR H04B OR A47F-009)/IPC/CPC
2	(((CONSUMER_TECH) OR ((FRONT-END) 1D (INTERFACE)) OR WEBSITE OR (MOBILE D (APP OR APPLICATION?)) OR ((DIGITAL OR MARKETING OR (CUSTOMER DATA)) D (SOFTWARE OR PLATFORM? OR PAYMENT?)) OR (GENERATIVE D (AI OR (ARTIFICIAL INTELLIGENCE))) OR CHATBOT? OR ((VIRTUAL OR AUGMENTED) D (REALITY))) F ((FOOD? OR FOODSTUFF? OR BEVERAGE? OR FOOD_TECH+ OR MEAL? OR CATERING OR FRUIT? OR VEGETABLE? OR MEAT? OR TAKEAWAY OR PERISHABLE? OR VICTUAL? OR EDIBLE? OR EATABLE? OR DRINK? OR ((AGRICULTUR+ OR AQUATIC) W PRODUCT?) OR CROP?)))/TI/AB/CLMS AND (G06Q-030 OR G06Q-010/08?? OR G06Q-010/02 OR G06Q-010/04 OR G06Q-020 OR G06Q-050 OR G06F OR G07F OR G07G OR B62B OR B65D OR B67D OR G06V OR G05B OR H04N OR H04B OR H04L OR G02B OR G06K OR G06T OR G05D)/IPC/CPC
3	A47J/IPC/CPC AND (MACHIN+ OR EQUIPMENT OR DEVICE OR ELECTR+ OR DIGITAL OR AUTOMAT+)/TI/AB/CLMS
4	((((AI OR (ARTIFICIAL INTELLIGENCE)) P (USER OR CONSUMER? OR CUSTOMER?))) F ((FOOD? OR FOODSTUFF? OR BEVERAGE? OR FOOD_TECH+ OR MEAL? OR CATERING OR FRUIT? OR VEGETABLE? OR MEAT? OR TAKEAWAY OR PERISHABLE? OR VICTUAL? OR EDIBLE? OR EATABLE? OR DRINK? OR ((AGRICULTUR+ OR AQUATIC) W PRODUCT?) OR CROP?)))/TI/AB/CLMS AND (G06Q-030 OR G06Q-010/08?? OR G06Q-010/02 OR G06Q-010/04 OR G06Q-020 OR G06Q-050 OR G06F OR G07F OR G07G OR B62B OR B65D OR B67D OR G06V OR G05B OR H04N OR H04B OR H04L OR G02B OR G06K OR G06T OR G05D)/IPC/CPC
5	1:4
6	5 AND EPD>2003
7	6 NOT NPN=1

Source: WIPO.

Delivery services

Delivery services are continually evolving to offer convenient options for ordering and delivering groceries and ready-to-eat meals to consumers or businesses, utilizing e-commerce, quick commerce (q-commerce) and delivery robotics.

S.No	Search string
1	((FOOD? OR FOODSTUFF? OR BEVERAGE? OR MEAL? OR MEAL_KIT? OR CATERING OR TAKEAWAY OR GROCERIES) D (DELIVER+))/TI/AB/CLMS NOT (A01? OR A21? OR A22? OR A23? OR A61?)/IPC/CPC
2	((FOOD? OR FOODSTUFF? OR BEVERAGE? OR MEAL? OR MEAL_KIT? OR CATERING OR TAKEAWAY OR ((TAKE_OUT?) 5D (FOOD? OR FOODSTUFF? OR BEVERAGE? OR MEAL? OR MEAL_KIT?)) OR ((RECIPE?) 5D (INGREDIENT? OR FOOD? OR FOODSTUFF? OR BEVERAGE? OR MEAL? OR MEAL_KIT?)) OR ((INGREDIENT?) 5D (FOOD? OR FOODSTUFF? OR BEVERAGE? OR MEAL? OR MEAL_KIT?)) OR GROCERIES) 3D (DELIVER+ OR ORDER+ OR DISTRIBUT+ OR SUPPLIER OR (THIRD_PARTY 1D PROVIDER?)))/TI/AB/CLMS AND (G06Q-05? OR G06Q-03? OR G06Q-01? OR G06Q-02? OR G07G OR H04?)/IPC/CPC
3	((FOOD? OR FOODSTUFF? OR BEVERAGE? OR MEAL? OR MEAL_KIT? OR CATERING OR TAKEAWAY OR ((TAKE_OUT?) 5D (FOOD? OR FOODSTUFF? OR BEVERAGE? OR MEAL? OR MEAL_KIT?)) OR ((RECIPE?) 5D (INGREDIENT? OR FOOD? OR FOODSTUFF? OR BEVERAGE? OR MEAL? OR MEAL_KIT?)) OR ((INGREDIENT?) 5D (FOOD? OR FOODSTUFF? OR BEVERAGE? OR MEAL? OR MEAL_KIT?)) OR GROCERIES) 3D (DELIVER+ OR ORDER+ OR DISTRIBUT+ OR SUPPLIER OR (THIRD_PARTY 1D PROVIDER?)))/TI/AB/CLMS AND (A47G-023/08 OR B25J OR B65G-035 OR G05D-001/02 OR G05D-001/2?? OR A47J-039 OR A47J-047/14 OR A45C-011/20)/IPC/CPC
4	((FOOD? OR FOODSTUFF? OR BEVERAGE? OR MEAL? OR MEAL_KIT? OR CATERING OR TAKEAWAY OR (TAKE_OUT?) OR ((RECIPE?) 5D (INGREDIENT? OR FOOD? OR FOODSTUFF? OR BEVERAGE? OR MEAL? OR MEAL_KIT?)) OR ((INGREDIENT?) 5D (FOOD? OR FOODSTUFF? OR BEVERAGE? OR MEAL? OR MEAL_KIT?)) OR GROCERIES) 3D (DELIVER+ OR ORDER+ OR DISTRIBUT+ OR DEMAND+ OR SUPPLIER OR (THIRD_PARTY 1D PROVIDER?) OR SUBSCRIPTION OR SUBSCRIBE+ OR TRANSPORT+ OR RESERVATION?) 3D (SYSTEM? OR SERVICE? OR APP? OR APPLICATION? OR WEBSITE?))/TI/AB/CLMS NOT (A01? OR A21? OR A22? OR A23? OR A61? OR B65? OR B67? OR C+)/IPC/CPC
5	(((RESTAURANT? OR CAFE? OR FAST_FOOD OR MARKETPLACE? OR WORKPLACE? OR (RECREATION?? FACILIT+) OR CANTEEN? OR STORES OR SUPERMARKET? OR BAR? OR KIOSK?) P (RESERVATION? OR RESERVE OR DELIVER+ OR ORDER+ OR SUBSCRIPTION OR SUBSCRIBE+) P (SYSTEM? OR SERVICE? OR APP? OR APPLICATION? OR WEBSITE? OR AI OR (ARTIFICIAL INTELLIGENCE)) P (FOOD? OR FOODSTUFF? OR BEVERAGE? OR MEAL? OR MEAL_KIT? OR CATERING OR TAKEAWAY OR (TAKE_OUT?)))/TI/AB/CLMS AND (G06Q OR G06F OR G07F OR G07G)/IPC/CPC) NOT (A01? OR A21? OR A22? OR A23? OR A61? OR B65? OR B67? OR C+)/IPC/CPC
6	1:5
7	6 AND EPD>2003
8	7 NOT NPN=1

Source: WIPO.

Food technology

Food technology encompasses equipment and processes for food production, excluding waste management, animal feed and consumer technology.

S.No	Search string
1	((B02C-009 OR B02C-011 OR A21B OR A21C OR A21D-006 OR A21D-008 OR A22C OR A23F OR A23G OR A23L-005 OR (A23N NOT A23N-017) OR A23P) NOT A47#)/IPC/CPC NOT (ANIMAL? OR PET? OR FEED?)/TI/AB
2	(C12M/IPC/CPC AND (EDIBLE OR FOOD OR BEVERAGE? OR BREW+)/TI/AB/CLMS) NOT WASTE/TI/AB/CLMS
3	((C12C OR C12F OR C12G OR C12H) NOT A47#)/IPC/CPC OR (C12J OR C12L OR C13#)/IPC/CPC
4	1:3 AND EPD>2003
5	4 NOT NPN=1

Source: WIPO.

Food chemistry

Food chemistry involves the development of new ingredients and food products, such as alternative proteins, functional foods, beverages and ready-to-eat meals.

S.No	Search string
1	(A21D-002 OR A21D-010 OR A21D-013 OR A21C-009 OR A23C-011 OR A23C-020 OR A23C-021 OR A23C-023 OR A23J OR A23L-002 OR A23L-007 OR A23L-009 OR A23L-011 OR A23L-013 OR A23L-015 OR A23L-017 OR A23L-019 OR A23L-021 OR A23L-023 OR A23L-025)/IPC/CPC
2	(A23C-013 OR A23C-015 OR A23C-017 OR A23C-019 OR A23D)/IPC/CPC NOT PRESERVA+/TI/AB
3	((C12N OR C12P OR C12R OR C12Y)/IPC/CPC AND (EDIBLE OR FOOD OR BEVERAGE? OR BREW+)/TI/AB/CLMS) NOT WASTE/TI/AB/CLMS
4	C08#/IPC/CPC AND (EDIBLE AND FOOD)/TI/AB/CLMS
5	A61K-036/IPC/CPC AND ((FOOD OR (FUNCTIONAL INGREDIENT?)) NOT (ANIMAL OR PET))/TI/AB/CLMS
6	C07H/IPC/CPC AND (EDIBLE AND FOOD)/TI/AB/CLMS
7	((C11B-001 OR C11B-003 OR C11B-005 OR C11B-007 OR C11B-015 OR C11C-001 OR C11C-003)/IPC/CPC AND (EDIBLE OR FOOD)/TI/AB/CLMS) NOT (WASTE OR USED OIL)/TI/AB/CLMS
8	1:7 AND EPD>2003
9	8 NOT NPN=1

Source: WIPO.

Food services

Food services are revolutionizing the hospitality industry by incorporating smart equipment and technologies like robotics and cloud kitchens.

S.No	Search string
1	(G06Q-050/12)/IPC/CPC
2	(((RESERVATION OR BOOKING OR RESERVING OR RESERVE) 3D (SYSTEM? OR PLATFORM? OR PORTAL?? OR APPLICATION? OR APPS OR ENGINE? OR SERVER?? OR SERVICE??))/TI/AB/CLMS/DESC/ODES/OBJ AND (FOOD OR FOODSTUFF? OR RESTAURANT? OR BEVERAGE? OR EATABLE? OR EATERIES OR EATERY OR BISTRO?? OR CAFE? OR DINER?)/TI/AB/CLMS/DESC/ODES/OBJ)
3	((G06Q-010/02)/IPC/CPC AND (FOOD OR RESTAURANT? OR BEVERAGE? OR EATABLE? OR EATERIES OR EATERY OR BISTRO?? OR CAFE? OR DINER? OR MEAL? OR FOODSTUFF? OR MEAT)/TI/AB/CLMS/DESC/ODES/OBJ)
4	((G06Q-010/063+)/IPC/CPC AND (FOOD OR RESTAURANT? OR BEVERAGE? OR EATABLE? OR EATERIES OR EATERY OR BISTRO?? OR CAFE? OR DINER? OR DINING)/TI/AB/CLMS/DESC/ODES/OBJ)
5	((MANAGE+ OR MANAGING OR MANAGED) 10D (RESTAURANT? OR DINING OR CAFE? OR DINER? OR CAFETERIA? OR MEAL?))/TI/AB/CLMS/DESC/ODES/OBJ
6	(FOOD_SERVICE_MANAGEMENT)/TI/AB/CLMS/DESC/ODES/OBJ
7	((MANAGE+ OR MANAGING OR MANAGED OR SUPERVIS+) 8D (SERVICE? OR DELIVERY OR DELIVERIES OR DELIVERED OR ORDER? OR BOOKING OR PAYMENT? OR PREPAR+ OR STORAGE OR STORING OR STORED) 8D (FOOD OR FOODSTUFF? OR EATABLE? OR BEVERAGE? OR PERISHABLE? OR MEAT))
8	1:7 AND EPD>2003
9	8 NOT NPN=1

Source: WIPO.

Supply chain

Supply chain solutions are being developed to optimize the food supply chain and food retail industry, with a focus on packaging, traceability and food waste management.

S.No	Search string
1	((A21? OR A22C OR A23? OR A01J)/IPC/CPC AND (((FOOD? OR FOODSTUFF? OR BEVERAGE? OR FOOD_TECH+ OR MEAL? OR CATERING OR FRUIT? OR VEGETABLE? OR MEAT? OR TAKEAWAY OR PERISHABLE? OR VICTUAL? OR EDIBLE? OR EATABLE? OR DRINK?) F (PROCESS+ OR PRODUCTION OR PRODUCE+ OR MANUFACTUR+ OR PROCURE+)) OR ((((AGRICULTUR+ OR AQUATIC) W PRODUCT?) OR CROP?) F (PROCESS+ OR PROCURE+)))/TI/AB/CLMS) NOT ((A23N-017 OR A23K OR A61? OR A47J)/IPC/CPC)
2	((B65? OR B67?)/IPC/CPC AND ((FOOD? OR FOODSTUFF? OR BEVERAGE? OR FOOD_TECH+ OR MEAL? OR CATERING OR FRUIT? OR VEGETABLE? OR MEAT? OR TAKEAWAY OR PERISHABLE? OR VICTUAL? OR EDIBLE? OR EATABLE? OR DRINK? OR ((AGRICULTUR+ OR AQUATIC) W PRODUCT?) OR CROP?)))/TI/AB/CLMS NOT (FOOD? D (WASTE OR RECYCL+ OR GARBAGE OR DISPOSAL OR REFUSE))/TI/AB/CLMS
3	((G06Q OR G06F OR G06K OR G06N OR G01N OR B60? OR B62? OR G05B)/IPC/CPC AND ((SUPPLY_CHAIN OR LOGISTIC+ OR INVENTORY OR INVENTORIES OR DISTRIBUT+ OR QUALITY OR DEMAND? OR SUPPLIER OR SUBCONTRACTOR? OR (THIRD_PARTY 1D PROVIDER?) OR CUSTOMER? OR TRANSPORTATION) P (FOOD? OR FOODSTUFF OR BEVERAGE? OR FOOD_TECH+ OR MEAL? OR CATERING OR FRUIT? OR VEGETABLE? OR MEAT? OR TAKEAWAY OR PERISHABLE? OR VICTUAL? OR EDIBLE? OR EATABLE? OR ((AGRICULTUR+ OR AQUATIC) W PRODUCT?) OR CROP? OR DRINK?))/TI/AB/CLMS) NOT (A61? OR B65F OR C05? OR C12N)/IPC/CPC
4	(A21D-004 OR A21D-015 OR A21D-017 ORA23B OR A23C-003 OR A23L-003)/IPC/CPC
5	(A23C-013 OR A23C-015 OR A23C-017 OR A23C-019 OR A23D)/IPC/CPC AND PRESERVA+/TI/AB
6	(FOOD? OR FOODSTUFF? OR BEVERAGE? OR FOOD_TECH+ OR MEAL? OR CATERING OR FRUIT? OR VEGETABLE? OR MEAT? OR TAKEAWAY OR PERISHABLE? OR VICTUAL? OR EDIBLE? OR EATABLE? OR DRINK?)/TI/AB/CLMS AND (SUPPLY CHAIN OR LOGISTIC? OR QUALITY CONTROL OR TRACEAB+ OR TRACKING)/KEYW/TI/AB
7	1:6 AND EPD>2003
8	7 NOT NPN=1

Source: WIPO.

B.3 Case studies

Non-pesticide pest and disease management

Non-pesticide pest and disease management focuses on alternative solutions to traditional pesticides, such as incorporating beneficial microbes into fertilizer formulations for biocontrol.

S.No	Search string
1	(((INSECT? OR PEST? OR HARMFUL+ OR PARASITE? OR PLANT+) S (CONTROL+ OR ATTRACT+ OR REPULS+ OR REPEL+ OR BIO_CONTROL+ OR EXTERMINAT+)))/TI/AB/ICLM AND (VOLATI+ OR "VOC" OR "VOCS")/TI/AB/CLMS/DESC
2	(A01N-03+ OR A01N-057+ OR A01N-059+ OR A01M-001+)/IPC/CPC
3	(PHEROM+ OR KAIROM+ OR SEMIO_CHE+ OR ALLOMON+ OR ALLELO_CHEM+)/TI/AB/CLMS AND ((INSECT? OR PEST? OR HARMFUL+ OR PARASITE? OR PLANT+) S (CONTROL+ OR ATTRACT+ OR REPULS+ OR REPEL+ OR BIO_CONTROL+ OR EXTERMINAT+))/TI/AB/CLMS/DESC/OBJ
4	(ALLOMON+ OR ALLELOCHEM+ OR ALLELO_CHEMIC+ OR PHEROMON+ OR KAIROM+)/TI/AB/CLMS
5	(((1 OR 4) AND 2) OR 3) NOT (HERBICID+/TI/AB/CLMS OR PESTICID+/TI/ICLM)
6	((BIOCONTROL AND (AGRI+ OR AGRO+))/TI/AB/CLMS NOT PESTICID+/TI/ICLM) NOT (A01N-027 OR A01N-029 OR A01N-031 OR A01N-033 OR A01N-035 OR A01N-037 OR A01N-039 OR A01N-041 OR A01N-043 OR A01N-045 OR A01N-047 OR A01N-049 OR A01N-051 OR A01N-053 OR A01N-055 OR A01N-057 OR A01N-059)/IPC/CPC
7	(A01N-063 OR A01N-065)/IPC/CPC NOT ((FOOD OR BEVERAGE?)/TI/AB/CLMS/OBJ/ADB OR HERBICID+/TI/AB/CLMS OR PESTICID+/TI/AB/ICLM)
8	((((CROP? OR CULTIVAR OR PLANT?) 1D (DISEASE? OR INFECTI+ OR PARASIT+ OR PEST?)) P (INHIBITI+ OR FIGHT+ OR MANAG+ OR CONTROL+ OR PREVENT+) P (NON_PESTICIDE OR BIOPESTICIDE? +BIOLOGIC+))/TI/AB/CLMS/OBJ/ADB) NOT HERBICID+/TI/AB/CLMS
9	((((C12N-001 OR C12R-001) AND A01P)/IPC/CPC AND ((DISEASE? OR INFECTI+ OR PARASIT+ OR PEST?) P (INHIBITI+ OR FIGHT+ OR MANAG+ OR CONTROL+ OR PREVENT+))) NOT (FOOD OR BEVERAGE?)/TI/AB/CLMS/OBJ/ADB) NOT A61+/IPC/CPC
10	A01M/CPC/IPC AND (NON_PESTICIDE/TI/AB/CLMS/OBJ/ADB/DESC OR (((PEST? OR INSECT? OR RODENT?) 2D (CATCH? OR KILL? OR PROTECT+ OR SCAR+ OR TRAP+))/TI/AB/CLMS NOT PESTICIDE?/TI/AB/CLMS/OBJ/ADB))
11	(EP2953469 OR EP4323496 OR EP3836788 OR EP3914068 OR EP3790955 OR EP3751991 OR EP3019014 OR US20090018194 OR EP1849361 OR EP3525593 OR CN108967423 OR KR101082640 OR CN117581870 OR TW200726405 OR CN202514458U OR KR200458885U OR KR101560095 OR WO200646067 OR US10617121 OR CN109511635 OR EP3772279 OR KR101029659 OR US20220151237 OR EP2347759 OR EP3508582 OR AU2013273706 OR US10017538 OR US11844353 OR CN105039326 OR EP2079314 OR IN202331064575 OR EP3413715)/XPN
12	..SIM SS 11
13	(12 AND (AGRI+ OR AGRO+ OR HORTICULTUR+ OR CROP? OR PLANT? OR CULTIVAR?)/TI/AB/CLMS AND (PEST? OR RODENT? OR INFECTIO+)/TI/AB/CLMS/OBJ) NOT (PESTICIDE?/TI/AB/CLMS OR (A01N-027 OR A01N-029 OR A01N-031 OR A01N-033 OR A01N-035 OR A01N-037 OR A01N-039 OR A01N-041 OR A01N-043 OR A01N-045 OR A01N-047 OR A01N-049 OR A01N-051 OR A01N-053 OR A01N-055 OR A01N-057 OR A01N-059)/IPC/CPC)
14	(EP2941488 OR EP02941488)/PN/AP/PR
15	..SIM SS 14
16	15 AND ((INSECT? OR PEST? OR PARASITE?) S (CONTROL+ OR REPULS+ OR REPEL+ OR BIO_CONTROL+ OR EXTERMINAT+ OR FIGHT+ OR KILL+ OR RESIST+))/TI/AB/ICLM
17	((PLANT? OR CROP? OR CULTIVAR?) D (RESISTANT 1D (PEST? OR DISEASE)))/TI/AB/CLMS
18	5:11 OR 13 OR 16 OR 17
19	18 AND EPD>2003
20	19 NOT (NPN=1 OR (WO2015168149 OR WO201455771 OR WO200722478 OR WO200569989 OR WO200607375 OR WO200439248 OR WO2020162926 OR WO2011100754 OR WO200879172 OR WO201914462 OR WO2010144678 OR WO2017214615 OR WO2017197280 OR CA3007299 OR CA2908227 OR WO2015113041 OR AU2007230902 OR US20050262584 OR WO2014124282 OR BR112015000660 OR WO2013170152 OR CA2864688 OR CA2863799 OR CA2848410 OR CA2851575 OR US20130189341 OR CA2793633 OR CA2793285 OR WO2010102140 OR US20110201265 OR AU2009308152 OR WO2009155477 OR WO2009148488 OR US20090202587 OR US20080008686 OR WO200767502 OR WO2006138478 OR WO2007130060 OR WO2006113907 OR WO200660193 OR AU2005284793 OR AU2005289957 OR AU2005282352 OR AU2005245899 OR WO200673432 OR AU2005206794 OR AU2004260681 OR WO2004111195 OR US20050196386)/XPN)

Source: WIPO.

Alternative nutrient sources for human food

Alternative nutrient sources for human consumption address the development and promotion of new nutritional options, such as cultured meat and plant-based proteins, to meet the challenges of population growth and resource limitations.

S.No	Search string
1	(A21D-002 OR A21D-010 OR A21D-013 OR A21C-009 OR A23C-011 OR A23C-020 OR A23C-021 OR A23C-023 OR A23J OR A23L-002 OR A23L-007 OR A23L-009 OR A23L-011 OR A23L-013 OR A23L-015 OR A23L-017 OR A23L-019 OR A23L-021 OR A23L-023 OR A23L-025)/IPC/CPC
2	(A23C-013 OR A23C-015 OR A23C-017 OR A23C-019 OR A23D)/IPC/CPC NOT PRESERVA+/TI/AB
3	((C12N OR C12P OR C12R OR C12Y)/IPC/CPC AND (EDIBLE OR FOOD OR BEVERAGE? OR BREW+)/TI/AB/CLMS) NOT WASTE/TI/AB/CLMS
4	C08#/IPC/CPC AND (EDIBLE AND FOOD)/TI/AB/CLMS
5	A61K-036/IPC/CPC AND ((FOOD OR (FUNCTIONAL INGREDIENT?)) NOT (ANIMAL OR PET))/TI/AB/CLMS
6	C07H/IPC/CPC AND (EDIBLE AND FOOD)/TI/AB/CLMS
7	((C11B-001 OR C11B-003 OR C11B-005 OR C11B-007 OR C11B-015 OR C11C-001 OR C11C-003)/IPC/CPC AND (EDIBLE OR FOOD)/TI/AB/CLMS) NOT (WASTE OR USED OIL)/TI/AB/CLMS
8	(1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7) AND EPD>2003
9	8 NOT NPN=1
10	(((MEAT+ OR BACON? OR SAUSAGE? OR LEAN OR FLESH OR PIG? OR PORK? OR BEEF OR LAMB? OR STEAK? OR CHICKEN OR FILLET? OR FILET? OR +BURGER? OR RIB? OR ROAST? OR CHORIZO OR EGG? OR POULTRY) 3D (SUBSTITUT+ OR ANALOG+ OR MIMIC? OR FAKE? OR REPLICA+ OR ALTERNATIV+ OR REPLAC+ OR PLANT+ OR VEGAN OR VEGETARIAN OR SIMULAT+ OR IMITAT+ OR MOCK OR NON_ANIMAL OR PRETEND OR RESEMBL+)) OR (MEAT_LESS OR MEAT_FREE OR MEAT_SUBSTITU+ OR MEAT_MIMIC+ OR MEAT_LIKE OR MEAT_REPLICA+ OR MEAT_MIMIC+ OR MEAT_SIMULAT+ OR MEAT_RESEMB+))/TI/AB/CLMS
11	((CULTIVAT+ OR LAB_GROWN OR CELL_BASED OR CLEAN OR SYNTHETIC+ OR CULTURE+ OR IN VITRO OR ARTIFICIAL OR SLAUGHTER_FREE OR CELL_CULTURED OR TISSUE_ENGINEER+ OR BIOFABRICAT+ OR CELLULAR OR PIONEERING OR SUSTAINABLE OR ETHICAL OR ALTERNATIVE OR LAB_CREAT+ OR ANIMAL_FREE OR BIOREACTOR OR ARTIFICIAL) 3D (MEAT OR BEEF OR GOAT OR PORK OR CHICKEN OR LAMB OR SAUSAGE OR BACON OR HAM OR STEAK OR FILLET OR FILET))/TI/AB/CLMS
12	((+CASEIN+ OR +LACTALBUMIN+ OR +LACTOGLOBULIN+ OR LACTOFERRIN OR WHEY_PROTEIN? OR MILK_PROTEIN? OR DAIRY OR MILK? OR BUTTER OR CHEES+ OR YOG?URT OR CREAM_CHEESE) S (NON_ANIMAL OR NON-ANIMAL OR ANIMAL-FREE OR ANIMAL_FREE OR ANALOG+ OR SUBSTITUT+ OR PLANT_BASED OR LIKE OR SIMULAT+ OR REPLAC+))/TI/AB/CLMS
13	(CHLOROPHYTA OR PRASINOPHYTA OR CAULERPA+ OR CAULERPA_LENTILLIFERA OR LATOK OR MONOSTROMA OR ULVA_LACTUCA OR ULVA OR SEA_LETTUCE OR LAVER? OR ULVA _INTESTINALIS OR ULVACEAE OR CHAETOMORPHA OR BRYOPSIS OR BRYOPSI+ OR CAPSOSIPHON_FULVESCENS OR CAPSOSIPHON OR ENTEROMORPHA OR ULVARIA OR CODIUM OR CODIUM_FRAGILE OR (DEAD D MAN?? D FINGER) OR PRASIOLA OR PRASIOLA_JAPONICA)/TI/AB/CLMS AND ((PROTEIN?)/TI/AB/CLMS OR (A23J+ OR A23L+ OR A23V+)/IPC/CPC)
14	(((SEA_FOOD OR SHELLFISH+ OR OYSTER+ OR CRUSTACEA+ OR LOBSTER+ OR MOLLUSC+) S (SUBSTITUT+ OR REPLAC+ OR FAK+ OR REPLICA+ OR ANALOG+ OR MIMIC+ OR SIMULAT+)) OR ((SEA_FOOD_LIKE OR SEA_FOOD_ANALOG+ OR SEA_FOOD_ANALOG+ OR SEA_FOOD_SUBSTIT+ OR SEA_FOOD_SIMULAT+) OR (FISH_LIKE OR FISH_ANALOG+ OR FISH_SUBSTIT+ OR FISH_SIMULAT+)))/TI/AB/CLMS
15	(((FISH+) S (SUBSTITUT+ OR REPLAC+ OR FAK+ OR REPLICA+ OR ANALOG+ OR MIMIC+ OR SIMULAT+ OR RESEMBL+)) OR ((SEA_FOOD_LIKE OR SEA_FOOD_ANALOG+ OR SEA_FOOD_ANALOG+ OR SEA_FOOD_SUBSTIT+ OR SEA_FOOD_SIMULAT+) OR (FISH_LIKE OR FISH_ANALOG+ OR FISH_SUBSTIT+ OR FISH_SIMULAT+)))/TI/AB/CLMS
	((LARVAE OR ALLOMYRIA OR DICHOTOMA OR ANAPHE_INFRACTA OR ANAPHE_RECTICULATA OR ANAPHE VENATA OR GONIMBRASIA_BELINA OR GYNAISA MAJA OR PROTAETIA OR BREVITARIS OR RHYNCHOPHORUS OR PHOENICIS OR TENEBRIO_MOLITOR OR BEETLE? OR HETEOLIGUS_MELES OR ORYCTES_BOAS OR RHYNCHOPHORUS OR PHOENICIS OR GRASSHOPPER OR RUSPOLIA_DIFFERENS OR CRICKET? OR ZONOCERUS OR VARIEGATUS OR BRACHYTRYPES OR GRYLLUS_BIMACULATUS OR TELEOGRYLLUS_EMMA OR TERMITE? OR MACROTERMES_BELLICOSUS OR MACROTERMES_FALCIGER OR

Source: WIPO.

16	MACROTERMES_NOTALENSIS OR BEE? OR APIS_MELLIFERA OR DRAGONFLY+ OR AESCHNA_MULTICOLOR OR CIRINA_FORDA OR GRYLLODES_SIGILLATUS OR SCHISTOCERCA_GREGARIA OR TENEBRIO_MOLITOR OR ORYCTES_OWARIENSIS OR HERMETIA_ILLUCENS OR ZOPHOBAS_MORIO OR ACHETA_DOMESTICUS OR BLAPTICA_DUBIA OR BOMBYX_MORI OR OXYA_VELOX OR OXYA_YEZOENSIS OR OXYA_JAPONICA OR VESPULA_LEWISII OR BOMBYX_MORI OR COCCOIDEA OR LOCUSTA_MIGRATORIA OR CICADAS OR ODONTOTERMES_FORMOSANUS OR ANAX_PARTHENOPE OR SAMIA_CYNTHIA OR CORIZUS_HYOSCYAMI OR SCHISTOCERCA_GREGARIA OR UDONGA_MONTANA OR OECOPHYLLA_SMARAGDINA OR MEIMUNA_OPALIFERA OR ALLONEMOBIUS_FASCIATUS OR ANUROGRYLLUS_ARBOREUS OR BELOSTOMATIDAE OR COTINIS_NITIDA OR OMPHISA_FUSCIDENTALIS OR RHYNCHOPHORUS_FERRUGINEUS OR ANAPHE_RETICULATE OR CIRINA_FORDA OR BRACHYTRUPES_MEMBRANACEUS OR ANAPHE_VENATA OR RHYNCHOPHORUS_PHOENICIS OR ANALEPTES_TRIFASCIATA OR ORYCTES_BOAS OR ORYCTES_MONOCEROS OR SILK_WORM? OR PSEUDACANTHOTERMES_MILITARIS OR (EDIBLE 2D INSECT?)))/TI/AB/CLMS AND ((PROTEIN?)/TI/AB/CLMS OR (A23J)/IPC/CPC)
17	((RED D ALGA+) OR RODOPHY+ OR EURHODOPHYTINA OR BANGIOPHYCEAE OR FLORIDEOPHYCEAE OR PROTEORHODOPHYTINA OR CYANIDIOPHYCEAE OR COMPSOPOGONOPHYCEAE OR PORPHYRIDIOPHYCEAE OR RHODELLOPHYCEAE OR STYLONEMATOPHYCEAE OR CYANIDIOPHYTINA OR CYANIDIOPHYCEAE OR BANGIALES OR GONIOTRICHALES OR HILDENBRANDIOPHYCIDAE OR HILDENBRANDIALES OR NEMALIOPHYCIDAE OR ACROCHAETIALES OR BALBIANIALES OR BALLIALES OR BATRACHOSPERMALES OR COLACONEMATALES OR NEMALIALES OR PALMARIALES OR ENTWISLEIALES OR THOREALES OR CORALLINOPHYCIDAE OR CORALLINALES OR RHODOGORGONALES OR HAPALIDIALES OR SPOROLITHALES OR AHNFELTIOPHYCIDAE OR AHNFELTIALES OR PIHIELLALES OR RHODYMENIOPHYCIDAE OR BONNEMAISONIALES OR CERAMIALES OR GELIDIALES OR GIGARTINALES OR GIGARTINA+ OR GRACILARIA+ OR GRACILARIA_CORONOPIFOLIA OR HALYMENIALES OR NEMASTOMATALES OR PEYSSONNELIALES OR PLOCAMIALES OR RHODYMENIALES OR ACROSYMPHYTALES OR ATRACTOPHORALES OR CATENELLOPSIDALES OR SEBDENIALES OR CYANIDIACEAE OR GALDIERIACEAE OR CYANIDIOSCHYZON OR GALDIERIA OR COMPSOPOGONALES OR ERYTHROPELTIDALES OR RHODOCHAETALES OR COMPSOPOGONACEAE OR COMPSOPOGONALES OR ERYTHROPELTIDACEAE OR GONIOTRICHACEAE OR PORPHYRIDIALES OR PORPHYRIDIUM OR CYANIDIOPHYTINA OR RHODELLA OR COMPSOPOGON OR STYLONEMA OR BANGIA OR HILDENBRANDIA OR NEMALION OR CORALLINA+ OR AHNFELTIA OR GELIDIUM OR PORPHYRA OR PYROPIA OR ACANTHOPHORA OR FURCELLARIA OR FURCELLARIA_LUMBRICALIS OR PALMARIA OR PALMARIA_PALMATA OR DULSE OR DILLISK OR DILSK OR CREATHNACH OR JANIA OR GRATELOUPIA_ELLIPTICA OR GRATELOUPIA OR LITHOTHAMNION_CALCAREUM OR LITHOTHAMNION OR LAURENCIA_UNDULATE OR LAURENCIA OR POLYOPES OR CALLOPHYLLIS OR KALLYMENIACEAE OR AGAROPHYTON_CHILENSIS OR AGAROPHYTON OR KAPPAPHYCUS_ALVAREZII OR KAPPAPHYCUS OR CHONDRUS OR EUCHEUMA)/TI/AB/CLMS AND ((PROTEIN?)/TI/AB/CLMS OR (A23J)/IPC/CPC)
18	((BROWN D ALGA+) OR PH?EOPHYC+ OR FUCUS OR FUCALES OR FUCUS_VESICULOSUS OR BLADDER_WRACK OR SEA_GRAPE? OR BLACK_TANG OR SEA_OAK OR CHORDA_FILUM OR CHORDA OR CHORDACEAE OR (DEAD D MAN?? D ROPE) OR LAMINARIA+ OR LAMINARIA_DIGITATA OR WAKAME OR OAR_WEED OR ASCOPHYLLUM_NODOSUM OR ASCOPHYLLUM OR SARGASSUM OR SARGASSUM_FUSIFORME OR HIJIKI OR HIZIKI OR HIZIKIA OR ECKLONIA OR ECKLONIA_KUROME OR ACROCARPIA OR ANTHOPHYCUS OR AXILLARIELLA OR BIFURCARIA OR BRASSICOPHYCUS OR CARPOGLOSSUM OR CARPOPHYLLUM OR CAULOCYSTIS OR COCCOPHORA OR CYSTOPHORA OR CYSTOSEIRA OR HALIDRYS OR HORMOPHYSA OR LANDSBURGIA OR MYAGROPSIS OR MYAGROPSIS_MYAGROIDES OR MYRIODESMA OR NIZAMUDDINIA OR OERSTEDTIA OR PALAEOHALIDRYS OR PHYLLOTRICHA OR PLATYTHALIA OR POLYCLADIA OR SARGASSOPSIS OR SARGASSUM OR TREVISAN OR SARGASSUM OR SCABERIA OR SIROPHYSALIS OR STEPHANOCYSTIS OR STOLONOPHORA OR TURBINARIA OR ABROTANIFOLIA OR ACINARIA OR ACYSTIS OR ALGOGRUNOWIA OR BACCALARIA OR BLOSSEVILLEA OR CARPACANTHUS OR CARPODESMIA OR CASTRALTIA OR CLADOPHYLLUM OR CYSTOPHYLLUM OR ENCHOPHORA OR GONGOLARIA OR HALOCHLOA OR HIZIKIA OR MONILIFERA OR MONILIFORMIA OR MYRIADENIA OR NEOPLATYLOBIUM OR NEUROTHALIA OR PHYLLACANTHA OR PLATYLOBIUM OR PTEROCAULON OR PYCNOPHYCUS OR SARGASSOPSIS OR NIZAMUDDIN OR SCAENOPHORA OR SPONGOCARPUS OR STICHOPHORA OR STOKEYIA OR TREPTACANTHA OR XIPHOPHYLLANTHUS OR MOZUKU OR NEMACYSTUS OR NEMACYSTUS_DECIPIENS OR RUGULOPTERYX OR RUGULOPTERYX_OKAMURAE OR SACCORHIZA OR SACCORHIZA_DERMATODEA OR SACCORHIZA_POLYSCHIDES OR ALARIA OR ALARIA_ESCULENTA OR KELP? OR DABBERLOCKS OR BADDERLOCKS OR DICTYOPTERIS OR DICTYOTACEAE OR PADINA OR SACCHARINA OR SACCHARINA_LATISSIMI OR DASHIMA OR DASIMA OR KOMBU OR KONBU OR HAIDAI OR SEA_TANGLE? OR UNDARIA OR ASCOPHYLLUM OR ASCOPHYLLUM_NODOSUM OR DURVILLAEA OR DURVILLAEA_ANTARCTICA OR LESSONIA OR LESSONIA_NIGRESCENS OR MACROCYSTIS)/TI/AB/CLMS AND (A23V OR A23J OR 23L)/IPC/CPC
19	(((GOLD OR GOLDEN) D ALGA+) OR CHRYSOPHYCEAE OR CHRYSOPHYT+ OR CHRYSOMONAD+ OR PRYMNESIUM OR XANTHOPHYL+ OR PHAEOTHAMNIOPHY+)/TI/AB/CLMS
20	((PLANT???)/TI/AB/CLMS AND (A23J)/IPC/CPC)
21	(10 OR 11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20) AND EPD>2003
22	21 NOT NPN=1
23	22 AND 9

Source: WIPO.

Predictive models in precision agriculture

Predictive models in precision agriculture involve developing AI-driven software to help farmers forecast market demands and optimize planting and irrigation plans, thereby enhancing the accuracy and efficiency of agricultural production.

S.No	Search string
1	((AGRICULTUR+ OR FARMING OR FARMED OR HORTICULTUR+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULT+) AND (ARTIFICIAL_INTELLIGENCE OR "AI" OR ((MACHINE OR DEEP) 2D LEARN+) OR NEURAL+_NETWORK+ OR ((NATURAL OR LARGE) D LANGUAGE? D (MODEL? OR PROCESS+ OR GENERAT+ OR UNDERSTAND+ OR PROGRAM+)) OR ((COMPUTER OR MACHINE) 2D VISION+) OR (MODEL OR ALGORITHM)))) /TI/AB/CLMS
2	((AGRICULTUR+ OR FARMING OR FARMED OR HORTICULTUR+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULT+) P (AUTOMATI+ OR AUTOMATED) P (SYSTEM? OR PROCESS+ OR PLATFORM?))/TI/AB/CLMS
3	(((CROP? OR CULTIVA+) AND (ARTIFICIAL_INTELLIGENCE OR "AI" OR ((MACHINE OR DEEP) 2D LEARN+) OR NEURAL+_NETWORK+ OR ((NATURAL OR LARGE) D LANGUAGE? D (MODEL? OR PROCESS+ OR GENERAT+ OR UNDERSTAND+ OR PROGRAM+)) OR ((COMPUTER OR MACHINE) 2D VISION+) OR (("NLP" OR "NLG" OR "NLU" OR "LLM" OR "CNN" OR "CCNN" OR "RNN" OR "RVNN") 2D (MODEL OR ALGORITHM)))) /TI/AB/CLMS AND (((HARVEST OR FARM+ OR AGRICULTUR+ OR HORTICULTUR+ OR ((CROP? OR CULTIVA+) P (PLANT? OR DISEASE? OR LAND))))/DESC OR (A01?)/IPC/CPC)) NOT ((A61? OR A01N OR A01P OR C12?)/IPC/CPC NOT (G06?)/IPC/CPC)
4	((CROP? OR CULTIVA+) P (AUTOMATI+ OR AUTOMATED) P (SYSTEM? OR PROCESS+ OR PLATFORM?))/TI/AB/CLMS AND (((CROP? OR CULTIVA+) P (HARVEST OR PLANT? OR FARM+ OR AGRICULTUR+ OR HORTICULTUR+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULTUR+ OR FRUIT? OR VEGETABLE? OR SEED? OR SEEDLING? OR FUNGI OR FUNGUS OR MUSHROOM?))/DESC OR (A01?)/IPC/CPC)
5	((AGRICULTUR+ OR FARMING OR FARMED OR HORTICULTUR+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULT+) P (AUTOMATI+ OR AUTOMATED) P (MACHINE+ OR EQUIPMENT? OR DEVICE OR APPARATUS))/TI/AB/CLMS
6	((CROP? OR CULTIVA+) P (AUTOMATI+ OR AUTOMATED) P (MACHINE+ OR EQUIPMENT? OR DEVICE OR APPARATUS))/TI/AB/CLMS AND (((CROP? OR CULTIVA+) P (HARVEST OR PLANT? OR FARM+ OR AGRICULTUR+ OR HORTICULTUR+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULTUR+ OR FRUIT? OR VEGETABLE? OR SEED? OR SEEDLING? OR FUNGI OR FUNGUS OR MUSHROOM?))/DESC OR (A01?)/IPC/CPC)
7	((AGRICULTUR+ OR FARMING OR FARMED OR HORTICULTUR+ OR CROP? OR CULTIVA+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULT+) P (SMART OR INTELLIGENT OR (REAL_TIME) OR IOT OR (INTERNET_OF_THINGS) OR MOBILE))/TI/AB/CLMS AND (A01?)/IPC/CPC
8	((AGRICULTUR+ OR FARMING OR FARMED OR HORTICULTUR+ OR CROP? OR CULTIVA+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULT+) P (SMART OR INTELLIGENT OR (REAL_TIME) OR IOT OR (INTERNET-OF-THINGS) OR MOBILE))/TI/AB/CLMS AND (G06Q OR G05D OR H04L OR G05B OR G06K OR G06F OR G06V)/IPC/CPC
9	1 OR 2 OR 3 OR 4 OR 5 OR 7 OR 6 OR 8
10	9 AND EPD>2003
11	10 NOT NPN=1
12	11 AND (PREDICTI+)/TI/AB/CLMS/OBJ/TX

Source: WIPO.

Autonomous devices in precision agriculture

Autonomous devices in precision agriculture explore the application of autonomous machinery and robotics technology to enhance efficiency in crop planting, management, and harvesting.

S.No	Search string
1	((AGRICULTUR+ OR FARMING OR FARMED OR HORTICULTUR+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULT+) P (AUTOMATI+ OR AUTOMATED) P (SYSTEM? OR PROCESS+ OR PLATFORM?))/TI/AB/CLMS
2	((CROP? OR CULTIVA+) P (AUTOMATI+ OR AUTOMATED) P (SYSTEM? OR PROCESS+ OR PLATFORM?))/TI/AB/CLMS AND (((CROP? OR CULTIVA+) P (HARVEST OR PLANT? OR FARM+ OR AGRICULTUR+ OR HORTICULTUR+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULTUR+ OR FRUIT? OR VEGETABLE? OR SEED? OR SEEDLING? OR FUNGI OR FUNGUS OR MUSHROOM?))/DESC OR (A01?)/IPC/CPC)
3	((AGRICULTUR+ OR FARMING OR FARMED OR HORTICULTUR+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULT+) P (AUTOMATI+ OR AUTOMATED) P (MACHINE+ OR EQUIPMENT? OR DEVICE OR APPARATUS))/TI/AB/CLMS
4	((CROP? OR CULTIVA+) P (AUTOMATI+ OR AUTOMATED) P (MACHINE+ OR EQUIPMENT? OR DEVICE OR APPARATUS))/TI/AB/CLMS AND (((CROP? OR CULTIVA+) P (HARVEST OR PLANT? OR FARM+ OR AGRICULTUR+ OR HORTICULTUR+ OR FARMLAND OR HUSBANDRY OR LIVESTOCK? OR POULTRY OR AQUACULTUR+ OR FRUIT? OR VEGETABLE? OR SEED? OR SEEDLING? OR FUNGI OR FUNGUS OR MUSHROOM?))/DESC OR (A01?)/IPC/CPC)
5	(1 OR 2 OR 3 OR 4)
6	5 AND EPD>2003
7	6 NOT NPN=1

Source: WIPO.

With the advent of innovative technologies, the Agrifood sector is undergoing a transformation which is pivotal in ensuring a sustainable food security system worldwide. These advances are set to revolutionize agricultural practices and food production, impacting economic, social, and environmental aspects.

The WIPO *Patent Landscape Report on Agrifood* looks at the latest patent trends in Agrifood, with a comprehensive and up-to-date understanding of the patent landscape in agricultural technology (AgriTech) and the food industry (FoodTech). The report also explores patents relating to the innovation and technological advancements in five case studies areas across the Agrifood sector.

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