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PRECISION AGRICULTURE FOR SUSTAINABLE FOOD PRODUCTION: MAPPING RESEARCH TRENDS

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ABSTRACT

Food systems are under pressure to produce more while using less land, water, fertilizer and pesticide, and precision agriculture has become one of the main technological answers to this problem. This study maps how research connecting precision agriculture and sustainable food production has developed, which themes structure the field, how they have shifted over time, and who drives the research. A bibliometric analysis was carried out on 518 Scopus-indexed documents published between 1989 and 2026. Keyword co-occurrence, overlay and density visualizations, co-authorship mapping at author, institution and country level, and citation analysis were performed with VOSviewer. The keyword map is anchored by sustainable agriculture and sustainable development and splits into four clusters: digital and precision technologies, food security and food systems, climate change and alternative production systems, and soil, nutrient and crop-protection science. The overlay map shows that smart agriculture, precision agriculture, machine learning, deep learning, artificial intelligence, hydroponics and soil health are the most recent themes, while organic farming, nutrient cycling and crop production belong to earlier work. The most cited studies, however, still come from agronomy, food safety, organic food, soil microbiology and agricultural policy. Author and institutional collaboration is concentrated in a few closed groups, while India, the United States, China and Pakistan lead a wide international network. The findings point to a field moving from agronomic sustainability toward data-driven decision support, and they highlight the need to connect digital tools with soil, nutrient and policy research.

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A. INTRODUCTION

Feeding a growing world population has become harder as farmland, water and soil fertility come under pressure from urban expansion, land degradation and climate change. Agriculture is asked to raise output and, at the same time, to cut its environmental footprint. Past gains in yield relied heavily on agricultural intensification and agrochemicals, which brought new risks such as nutrient losses, water eutrophication and contamination of soils and food chains. Population growth of close to one percent a year continues to push food and fibre demand upward, while climate change adds uncertainty to yields and farm incomes (Sithole et al., 2026). Rising input costs, market volatility and extreme weather events make the case for production systems that use resources more carefully and respond faster to changing field conditions (Mudzielwana, 2025).

Precision agriculture is one of the most widely discussed responses to this challenge. The approach manages farms at the level of the field or plant rather than the whole farm, matching nutrients, agrochemicals and water to soil fertility, crop needs and local growing conditions. Through variable-rate application, precision agriculture aims to lower yield losses, reduce greenhouse-gas emissions and nutrient leaching, and improve the

footprint of farm inputs (Zaman, 2023). Unmanned aerial vehicles, satellite remote sensing and machine-learning models now provide high-resolution data on crop health, soil condition and pest pressure, which can be turned into decisions on yield prediction, fertilization and irrigation (Xing et al., 2026). Reviews report that data-driven precision methods can cut resource use by 20–30% and raise water-use efficiency by up to about 40% (Manimozhi & Krishnamoorthy, 2025), and that drone-based spraying can reduce pesticide use by 30–65% compared with knapsack spraying (Patil et al., 2024).

Digital technologies have widened the scope of precision agriculture well beyond machinery guidance. Deep-learning models are used to identify plant diseases and recommend treatment, which supports faster responses to one of the main threats to crop yields (Isinkaye et al., 2024). Remote sensing and machine learning are also applied to controlled-environment agriculture, where they help improve resource efficiency and process control (Coman et al., 2025). Across these applications, the common aim is to turn large volumes of field and crop data into timely decisions on irrigation, fertilization and crop protection (Xing et al., 2026). Digital tools are also reaching smallholders, where they help farmers cope with climate risks and improve access to markets, credit and information (Sithole et al., 2026).

Precision technologies are increasingly discussed alongside other sustainability approaches rather than as stand-alone tools. Precision agroecology, for example, combines data collection, field experimentation and decision-support tools with agroecological principles to reduce inputs and bring biodiversity back into farm systems (Duff et al., 2022). Climate-smart agriculture links adaptation and mitigation practices with precision tools, although adoption depends heavily on finance, technical support and policy (Mudzielwana, 2025), and digital tools have been shown to strengthen farmer resilience and market access in climate-smart systems (Sithole et al., 2026). Precision thinking has also entered nutrient management, through target-specific compost strategies, algae biofertilisers and plant growth-promoting microbes (Chandran et al., 2021; Rupawalla et al., 2021; Zhao et al., 2022).

This literature has grown quickly but remains scattered across agronomy, soil science, food science, environmental policy, computer science and engineering. Earlier bibliometric studies have tended to cover one technology or one outcome: remote sensing and machine learning in agriculture (Coman et al., 2025), drones for fertilizer and pesticide application (Patil et al., 2024), and digital technology adoption and its link to the second Sustainable Development Goal (Florez et al., 2026). These studies show that digital agriculture research tends to focus on productivity and efficiency, while the sustainability dimensions of adoption receive less attention (Florez et al., 2026). What is missing is a joint picture of how precision and smart technologies sit within the wider body of research on sustainable food production, which themes are mature, which are emerging, and which research groups shape the field.

This study addresses that gap through a bibliometric mapping of research on precision agriculture for sustainable food production. It asks three questions: (1) which thematic clusters make up the intellectual structure of the field; (2) how research themes have shifted over time; and (3) which authors, institutions and publications have been most influential. The analysis combines keyword co-occurrence, overlay and density visualization, co-authorship mapping and citation analysis. The results are expected to give researchers a clearer view of where precision agriculture fits in the sustainable food production agenda and to point policymakers and practitioners toward topics that still need stronger evidence.

B. METHOD

This study used a bibliometric design to map the structure and development of research on precision agriculture for sustainable food production. Bibliographic data were retrieved from the Scopus database, which was chosen for its wide coverage of peer-reviewed journals, books and conference proceedings and for its consistent metadata. The search was run on the title, abstract and keyword fields using terms related to sustainable food production and sustainable agriculture, so that technology-oriented studies such as precision agriculture, smart farming, machine learning and hydroponics were captured together with the agronomic, environmental and policy research to which they are linked. The records were exported on 2 October 2026 in RIS format and screened for duplicates and incomplete entries.

The final dataset contained 518 documents published between 1989 and 2026, together with one record already assigned to a 2027 issue. It consisted of 197 journal articles, 136 book chapters, 110 reviews, 41

conference papers, 26 books and 8 other documents (editorials, notes and short surveys), and 508 of the documents were written in English. Publication output rose sharply in recent years, with 83 documents in 2024, 159 in 2025 and 100 in 2026 up to the export date. The documents had received 11,649 citations in total. Each record included author names, affiliations, title, abstract, author and index keywords, source, year, citation count and DOI, which allowed both performance and science-mapping analyses.

Science mapping was carried out with VOSviewer. Keyword co-occurrence analysis was used to identify thematic clusters, and the results were shown as network, overlay and density visualizations. In the network map, node size reflects keyword frequency, link thickness reflects co-occurrence strength and colours mark clusters; the overlay map colours each keyword by the average publication year of the documents in which it appears; and the density map shows where keywords concentrate. Only keywords meeting the minimum occurrence threshold were kept, and generic or duplicate terms were reviewed during interpretation. Co-authorship analysis was performed at the author and institution level to describe collaboration patterns, while citation analysis was used to rank the most influential documents in the dataset.

C. RESULTS AND DISCUSSION

1. Keyword Co-Occurrence Network

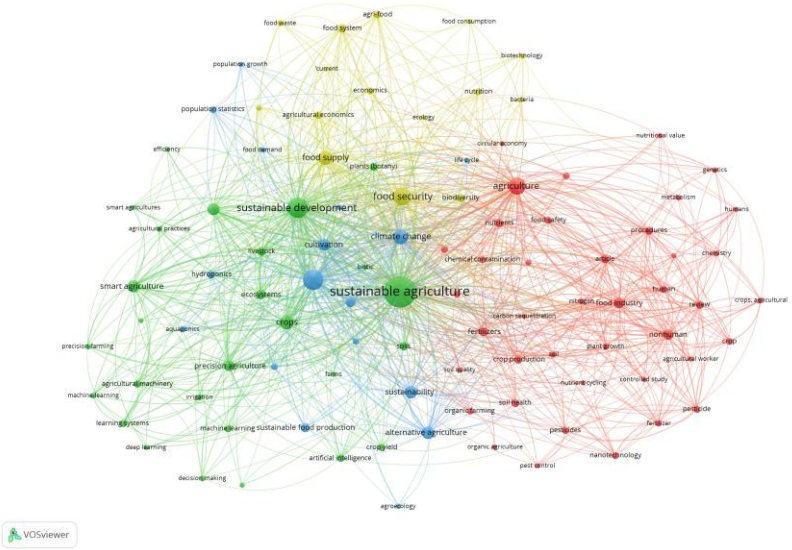


Figure 1. Network Visualization
Source: Data Analysis Result, 2026

Figure 1 presents the keyword co-occurrence network of research on precision agriculture for sustainable food production. The map is dense and strongly connected, showing that the field links technology, food supply, environmental change and agronomy rather than treating them as separate topics. “Sustainable agriculture” is the largest and most central node, followed by “sustainable development”, “agriculture”, “food security”, “climate change” and “food supply”. Their central position shows that most studies frame precision and smart technologies as tools for broader sustainability goals rather than as engineering topics on their own. The green cluster gathers the technology-oriented strand of the field. It contains smart agriculture, smart agricultures, precision agriculture, precision-farming, agricultural machinery, irrigation, machine learning, deep learning, learning systems, artificial intelligence and decision making, together with crops, crop yield, livestock, ecosystems, soils and agricultural practices. This grouping shows that digital tools are mostly studied in relation to field-level decisions on crops, water and farm operations.

The yellow cluster deals with food systems and their economic side. Keywords such as food security, food supply, food system, agri-food, food waste, food consumption, economics, agricultural economics, nutrition, biotechnology, ecology and biodiversity indicate that a large part of the literature asks how changes in production translate into food availability, consumption and economic outcomes. The blue cluster brings together climate change, cultivation, sustainability, alternative agriculture, sustainable food production,

hydroponics, aquaponics, agroecology, life cycle, food demand, population growth and population statistics. Its position between the technology cluster and the food-system cluster suggests that alternative production systems and climate adaptation act as a bridge between farm-level innovation and the demand-side pressures that motivate it.

The red cluster, located on the right side of the map, represents the agronomic and life-science base of the field. It includes fertilizers, fertilizer, crop production, soil health, soil quality, nutrients, nutrient cycling, nitrogen, carbon sequestration, plant growth, pesticides, pest control, organic farming, organic agriculture, nanotechnology, food safety, chemical contamination and food industry, along with database descriptors such as nonhuman, controlled study, article and review. These terms show that much of the research still focuses on the biological and chemical processes that precision tools are meant to manage, such as fertilizer efficiency, soil condition and pesticide reduction. Taken together, the four clusters show a field built on a large agronomic foundation, with digital technology forming a growing but still distinct branch.

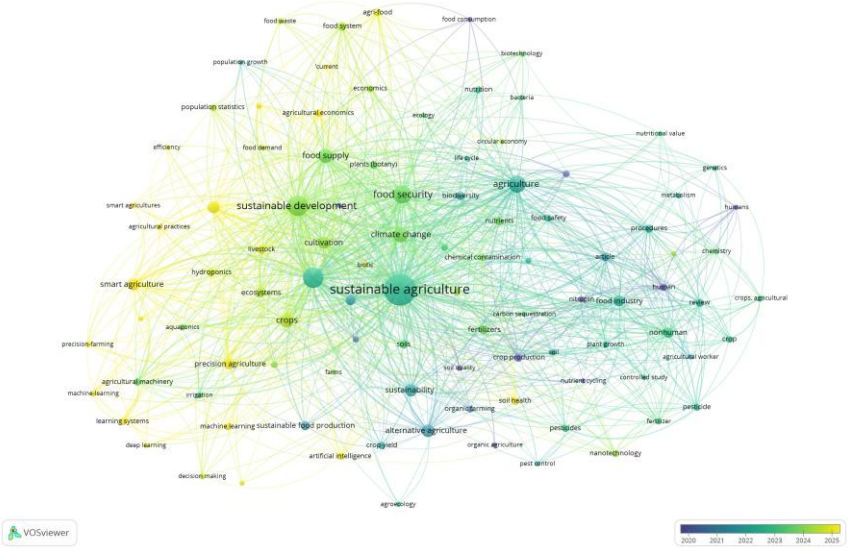


Figure 2. Overlay Visualization
Source: Data Analysis Result, 2026

Figure 2 shows the overlay visualization, in which keywords are coloured according to the average publication year of the documents in which they occur, from about 2020 (dark blue and purple) to 2025 (yellow). Older themes appear on the right and lower part of the map. Keywords such as food consumption, humans, human, nitrogen, crop production, soil quality, nutrient cycling, organic agriculture and organic farming carry purple and blue tones, suggesting that earlier work focused on nutrient management, organic production and the health dimension of food. Sustainable agriculture, agriculture, sustainability, alternative agriculture, sustainable food production, crop yield, food industry and pesticide sit in the teal range, which marks them as long-standing core themes that continue to be studied.

The most recent keywords are concentrated on the left side of the map. Smart agriculture, smart agricultures, precision agriculture, precision-farming, machine learning, machine-learning, deep learning, learning systems, artificial intelligence, decision making, agricultural practices, efficiency and hydroponics appear in yellow, showing that digital and data-driven farming has become the main growth area in the last two years. Soil health, agricultural economics, food demand, agri-food and population statistics also appear in yellow or light green, while sustainable development, food security, food supply, food system, climate change and cultivation fall in the green range of 2023 to 2024.

This temporal pattern points to a clear shift in research focus. Earlier studies concentrated on how to produce food sustainably through organic practices, nutrient cycling and crop production, while more recent studies ask how digital tools, artificial intelligence and precision equipment can support these goals. The appearance of soil health and nanotechnology in recent colours also shows that newer work is starting to connect precision tools with soil and input management. The left-to-right colour gradient suggests that the

technology cluster is the youngest part of the field and is still being linked to the older agronomic and food-system research.

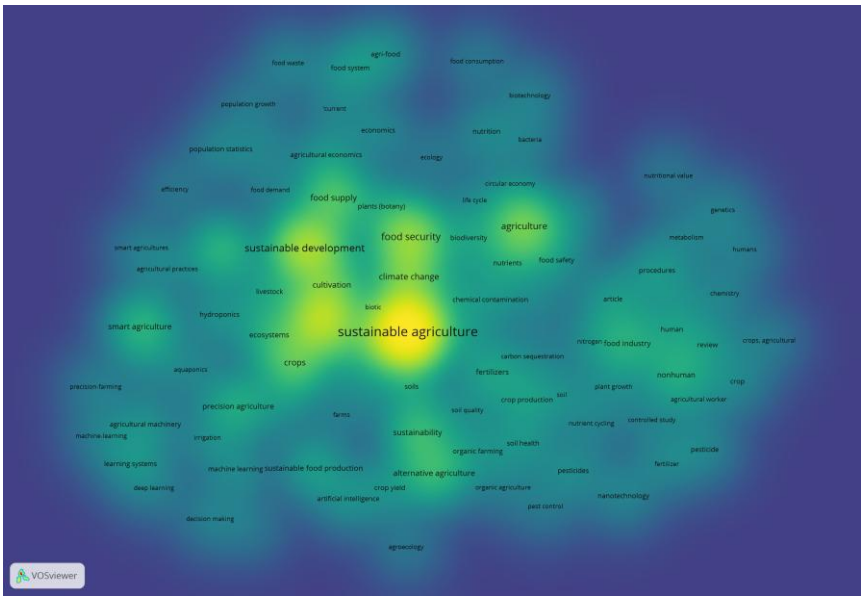


Figure 3. Density Visualization
Source: Data Analysis Result, 2026

Figure 3 presents the density visualization, where brighter areas show keywords that occur more often and have stronger connections. The brightest zone is centred on “sustainable agriculture”, followed by sustainable development, food security, food supply, cultivation, climate change and agriculture. Bright areas also appear around crops, sustainability and alternative agriculture. These terms form the core of the field and show that research on precision technologies is framed mainly through sustainability, food availability and climate concerns.

Smart agriculture, precision agriculture, food industry and nonhuman form secondary areas of moderate density, while keywords such as machine learning, deep learning, artificial intelligence, agricultural machinery, hydroponics, aquaponics, nanotechnology, pesticides, soil health and agroecology lie in darker zones at the edges of the map. These peripheral terms are either newer or more specialized topics. Their low density, combined with their recent position in the overlay map, suggests that precision and smart farming technologies are growing fields that have not yet reached the same level of maturity as the core sustainability themes, which leaves room for further research.

2. Co-Authorship Analysis

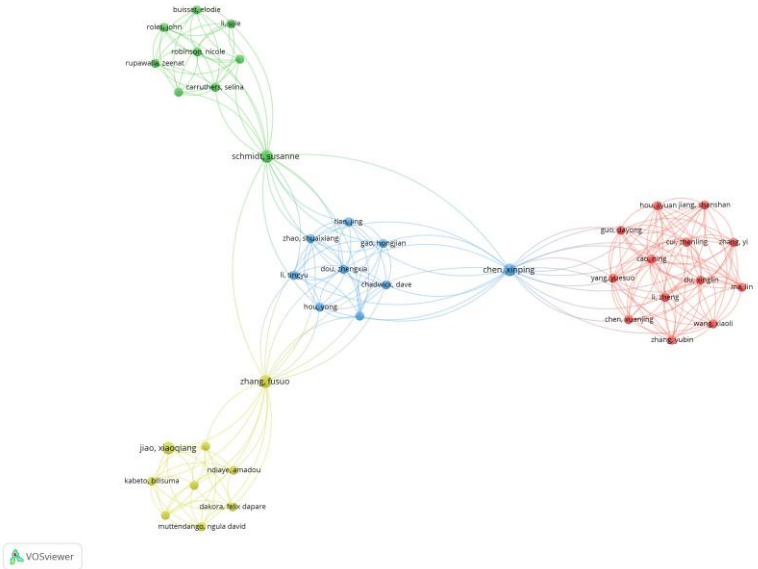


Figure 4. Author Visualization
Source: Data Analysis Result, 2026

Figure 4 shows the co-authorship network among researchers. The network consists of four clusters that are internally dense but connected to one another through only a few authors. The red cluster on the right is the largest and most tightly knit group. It includes Cao Ning, Cui Zhenling, Zhang Yi, Guo Dayong, Hou Liyuan, Jiang Shanshan, Yang Yuesuo, Du Xinlin, Li Zheng, Ma Lin, Chen Xuanjing, Wang Xiaoli and Zhang Yubin, and reflects multi-author work on organic phosphorus strategies that combine target crops and growing environments to raise food production and reduce phosphorus losses (Li et al., 2026).

The blue cluster in the middle includes Tian Jing, Zhao Shuaixiang, Gao Hongjian, Li Tingyu, Dou Zhengxia, Chadwick Dave and Hou Yong, with Chen Xinping acting as the main hub that connects the blue and red clusters. This group is associated with the precision compost strategy, which aligns compost types and application methods with target crops and growing conditions to raise global food production (Zhao et al., 2022). The green cluster at the top, centred on Schmidt Susanne, includes Rupawalla Zeenat, Robinson Nicole, Buisset Elodie, Roles John, Li Sijie and Carruthers Selina, and is linked to work on algae biofertilisers for sustainable food production and a circular nutrient economy (Rupawalla et al., 2021).

The yellow cluster at the bottom is organized around Zhang Fusuo and Jiao Xiaoqiang, with Ndiaye Amadou, Kabeto Bilisuma, Dakora Felix Dapare and Muttendango Ngula David. It reflects research on the Science and Technology Backyard model and its use for sustainable agriculture in Africa (Jiao et al., 2020). Zhang Fusuo and Schmidt Susanne act as bridges toward the blue cluster through joint work on precision compost. The network therefore shows that collaboration is concentrated in a small number of groups, many of them linked to Chinese plant-nutrition research, and that ties between groups depend on a few key researchers. Precision nutrient management is the common thread across these groups, while authors working on digital tools do not yet appear as a connected community.

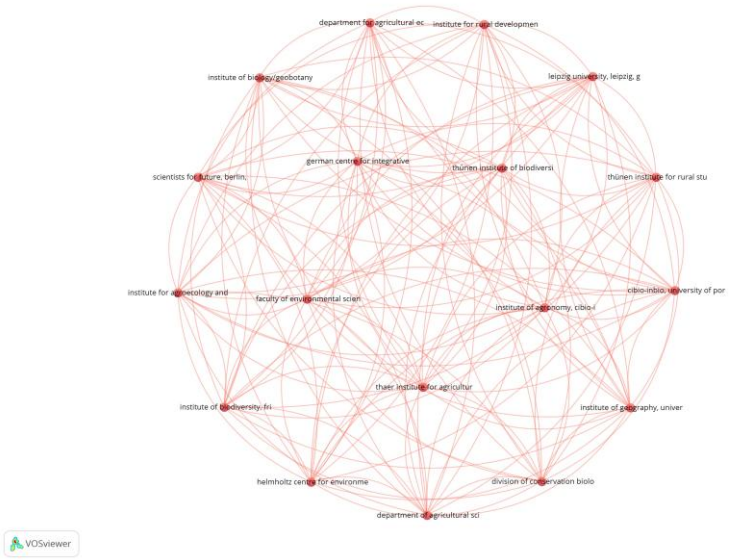


Figure 5. Institution Visualization
Source: Data Analysis Result, 2026

Figure 5 displays the institutional collaboration network. All institutions shown belong to one red cluster in which almost every node is linked to every other node. The network includes the German Centre for Integrative Biodiversity Research (iDiv), the Helmholtz Centre for Environmental Research (UFZ), Leipzig University, the Institute of Biodiversity at Friedrich Schiller University Jena, the Institute of Biology/Geobotany at Martin Luther University Halle-Wittenberg, the Thünen Institute of Biodiversity, the Thünen Institute for Rural Studies, the Thaer Institute for Agricultural and Horticultural Sciences, Scientists for Future Berlin, the Institute for Rural Development Research, the Institute for Agroecology and Biodiversity, and the Department for Agricultural Economics and Rural Development at the University of Göttingen. Institutions outside Germany include the University of Helsinki, CIBIO-InBIO at the Universities of Porto and Lisbon, the University of Innsbruck, the University of Vienna and the Czech University of Life Sciences Prague.

This complete-graph pattern is typical of a single highly cited multi-institution paper rather than a stable, wide collaboration structure. The institutions are connected through the joint assessment of the European Union Common Agricultural Policy and its ability to address sustainability challenges (Pe'er et al., 2020). The network shows the strong role of European biodiversity, agroecology and agricultural policy institutions, while research centres from Asia, Africa and the Americas, where much of the recent precision agriculture output comes from, do not appear in the main collaborative structure. Institutional collaboration in the field is therefore still limited and concentrated in policy-oriented networks.

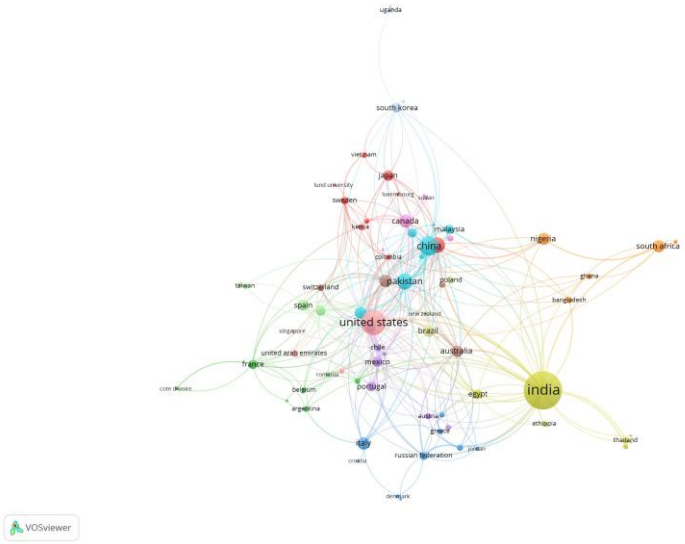


Figure 6. Country Visualization
Source: Data Analysis Result, 2026

Figure 6 presents the country collaboration network. India is the largest node and stands out as the most productive country, which is consistent with the dataset, where 170 documents list at least one Indian affiliation. The United States is the second largest node, with 72 documents, and occupies the most central position in the map, with links to almost every other cluster. China (44 documents) and Pakistan (29 documents) form a strong cyan cluster together with Malaysia, and both lie close to the United States, showing frequent joint work among these countries. India forms its own yellow cluster with Egypt, Ethiopia and Thailand and is linked to many countries through long connecting lines, although its position at the edge of the map suggests that much Indian output is still produced through domestic or regional collaboration.

Several smaller clusters complete the network. Nigeria, South Africa, Ghana and Bangladesh form an orange cluster on the right, reflecting growing African participation in research on sustainable food production. Japan, Sweden, Kenya, Viet Nam and Colombia make up a red cluster, while Canada and Sudan form a pink group near the centre. Australia, Switzerland and Poland belong to a brown cluster, and Brazil is positioned close to the United States. European countries are spread across several groups: France, Belgium, Argentina and Cote d'Ivoire form a green cluster; Spain and Taiwan sit in a light green group; Mexico, Chile, Portugal and Austria form a purple cluster; and Italy, the Russian Federation, Jordan, Greece, Croatia and Denmark form a blue cluster. South Korea and Uganda appear at the top of the map with only a few links.

The country map shows a much wider pattern of cooperation than the author and institution maps. Research on precision agriculture for sustainable food production is truly international, with participation from Asia, Africa, Europe, Oceania and the Americas, and the many links that pass through the United States, China and Pakistan show their role as bridges between regions. At the same time, many countries in Africa, Southeast Asia and Eastern Europe are represented by small nodes with few links, which indicates uneven research capacity. The appearance of “Lund University” as a country node also shows that some affiliation records in Scopus are incomplete, so the country results should be read with this limitation in mind.

3. Citation Analysis

Table 1. Top Cited Research

Citations	Author and year	Title
540	(Türkan & Demiral, 2009)	Recent developments in understanding salinity tolerance
495	(Pe'er et al., 2020)	Action needed for the EU Common Agricultural Policy to address sustainability challenges
493	(Jarosz, 2008)	The city in the country: Growing alternative food networks in Metropolitan areas

422	(Bourke et al., 2018)	The Potential of Cold Plasma for Safe and Sustainable Food Production
330	(Lairon, 2010)	Nutritional quality and safety of organic food. A review
325	(Garcia et al., 2020)	One Health for Food Safety, Food Security, and Sustainable Food Production
255	(Çakmakçı et al., 2023)	Assessment and Principles of Environmentally Sustainable Food and Agriculture Systems
241	(Aguilar-Paredes et al., 2023)	Microbial Community in the Composting Process and Its Positive Impact on the Soil Biota in Sustainable Agriculture
225	(Lu et al., 2000)	Cover crops in sustainable food production
223	(Chandran et al., 2021)	Plant growth-promoting rhizobacteria as a green alternative for sustainable agriculture

Source: Scopus, 2026

Table 1 lists the ten most cited documents in the dataset. The most cited work is the review of salinity tolerance mechanisms (Türkan & Demiral, 2009) with 540 citations, followed by the call for reform of the European Union Common Agricultural Policy (Pe'er et al., 2020) with 495 citations and the study of alternative food networks in metropolitan areas (Jarosz, 2008) with 493 citations. Other highly cited studies include the potential of cold plasma for safe and sustainable food production (Bourke et al., 2018), the nutritional quality and safety of organic food (Lairon, 2010) and the One Health approach linking food safety, food security and sustainable food production (Garcia et al., 2020).

The remaining studies deal with principles of environmentally sustainable food and agriculture systems (Çakmakçı et al., 2023), the role of composting microbes in soil biota (Aguilar-Paredes et al., 2023), cover crops in sustainable food production (Lu et al., 2000) and plant growth-promoting rhizobacteria as a green alternative for sustainable agriculture (Chandran et al., 2021). None of the ten most cited documents is mainly about precision or digital technology. This confirms that the intellectual base of the field lies in plant physiology, soil microbiology, food safety, organic production and agricultural policy. Precision agriculture studies are newer and have not yet had enough time to accumulate citations, which matches their recent position in the overlay map.

4. Discussion

The bibliometric results show that research on precision agriculture for sustainable food production has grown into an interdisciplinary field that connects digital technology with agronomy, food systems, climate change and agricultural policy. Keyword co-occurrence analysis places sustainable agriculture and sustainable development at the centre of the network, with precision and smart agriculture forming a separate but well-connected technology cluster. This means that precision technologies are studied mainly as means to reach sustainability goals rather than as ends in themselves, which is in line with the view of precision agriculture as a pathway toward sustainable agriculture (Zaman, 2023).

The technology cluster brings together precision agriculture, machine learning, deep learning, artificial intelligence, irrigation and agricultural machinery. Its focus on data-driven decisions for crops and water supports the conclusion that UAVs, satellite remote sensing and machine learning work best when combined to guide yield prediction, nutrient management and irrigation (Xing et al., 2026). Practical gains reported in the literature, such as lower resource use, better water efficiency and reduced pesticide application (Manimozhi & Krishnamoorthy, 2025; Patil et al., 2024), explain why the technology cluster has expanded quickly. The presence of decision making in the same cluster also matches the growing interest in decision-support systems that turn field data into management choices (Coman et al., 2025).

The overlay analysis shows a clear move from earlier themes such as organic farming, nutrient cycling, crop production and soil quality toward recent themes such as smart agriculture, machine learning, deep learning, artificial intelligence and hydroponics. This shift is consistent with recent work on deep learning for disease detection (Isinkaye et al., 2024) and on the combined use of UAVs, satellite data and machine learning for precision decisions (Xing et al., 2026). The recent growth of hydroponics also matches the rising interest in

controlled-environment agriculture as a resource-efficient production option supported by sensing and machine learning (Coman et al., 2025; Manimozhi & Krishnamoorthy, 2025).

A notable finding is the gap between the most active themes and the most cited works. The top-cited documents deal with salinity tolerance, organic food quality, cold plasma, plant growth-promoting rhizobacteria, cover crops and agricultural policy (Bourke et al., 2018; Chandran et al., 2021; Lairon, 2010; Lu et al., 2000; Pe'er et al., 2020; Türkan & Demiral, 2009). Precision technologies therefore rest on a knowledge base built by agronomy, soil microbiology and food science. The links between the red agronomic cluster and the green technology cluster suggest that the next stage of the field lies in applying precision tools to soil health, fertilizer efficiency and biological inputs. Precision compost strategies, algae biofertilisers and organic phosphorus management already show how precise targeting of inputs to crops and environments can raise output while lowering losses (Li et al., 2026; Rupawalla et al., 2021; Zhao et al., 2022).

The density map shows that sustainability, food security and climate change remain the most intensively studied areas, while digital technologies, soilless production and nanotechnology occupy less dense, peripheral positions. This indicates that the technical strand is still young and fragmented. Precision agroecology offers one way to bring these strands closer, by combining variable-rate technology and precision conservation with agroecological principles (Duff et al., 2022). Climate-smart agriculture provides another bridge, as digital tools can help farmers adapt to climate risks while improving productivity and access to markets (Mudzielwana, 2025; Sithole et al., 2026).

The collaboration analysis adds a further perspective. Author collaboration is concentrated in four closed groups, most of them linked to plant-nutrition research, and the institutional map is dominated by a single European policy network. The country map, by contrast, shows a broad network in which India, the United States, China and Pakistan play leading roles and countries in Africa, Latin America and Southeast Asia take part, which matches the geographic spread of studies on smart farming and digital adoption in these regions (Jiao et al., 2020; Sithole et al., 2026). Collaboration across countries is therefore wider than collaboration across research groups, which remain small and specialized. Adoption of climate-smart and precision practices is shaped by finance, technical support and policy (Mudzielwana, 2025), and the link between digital adoption and the Sustainable Development Goals is still unevenly studied (Florez et al., 2026). Stronger collaboration between technology developers, agronomists, social scientists and policy researchers would help turn precision tools into practical gains for sustainable food production.

D. CONCLUSION

This study mapped research trends on precision agriculture for sustainable food production using 518 Scopus documents. The field is anchored by sustainable agriculture and sustainable development and is organized into four thematic clusters: digital and precision technologies, food security and food systems, climate change and alternative production systems, and the agronomic base of soil, nutrients and crop protection. Temporal analysis shows that smart agriculture, precision agriculture, machine learning, deep learning, artificial intelligence, hydroponics and soil health are the most recent themes, while organic farming, nutrient cycling and crop production belong to earlier work. Citation analysis shows that the most influential studies still come from plant physiology, soil microbiology, food safety, organic food and agricultural policy, Author and institutional collaboration remains concentrated in a few groups and one European network, although the country map shows a wide international structure led by India, the United States, China and Pakistan.

These findings suggest that future research should link precision tools more closely with soil health, nutrient management and biological inputs, test digital solutions under the conditions of smallholder and resource-poor farming systems, and examine the institutional and economic factors that shape adoption. Policymakers can use the map to direct support toward data-driven input management and capacity building. This study relies on a single database and on keyword-based mapping, so relevant work indexed elsewhere may be missing and recent publications are under-represented in citation counts. Future studies could combine Scopus with Web of Science, apply co-citation and bibliographic coupling analyses, and clean affiliation data more thoroughly to give a fuller picture of the field.

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