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Mapping the Scientific Labour Organization in Agricultural and Remote Sensing Research

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ABSTRACT
Scientific labour organization is becoming relevant in the context of the rapidly changing requirements of the modern market, especially in the growing human interaction with robotic systems and artificial intelligence. The purpose of this study is to conduct a bibliometric and content analysis of scientific labour organization in agriculture, with a focus on the integration of remote sensing technologies and precision farming. The methodological basis of the work included bibliometric and content analysis of scientific articles selected from the Web of Science database for the period 1992-2025, using clusterization (CiteSpace 6.3.R1). The results showed a steady increase in publication activity: since 2017, the number of papers has increased to four per year, and the peak of citations occurred in 2022. Cluster analysis revealed two dominant areas: “Industry 4.0” (77 articles, the average publication year is 2016, S = 0.99) and “Precision Agriculture” (34 articles, the average year is 2014, S = 1.0). These clusters have shown that sustainable land use technologies and precision farming innovations are changing the organization of labor and management of agricultural enterprises. The results demonstrate the growing interest in the problems of labor organization in the context of the digitalization of the agricultural sector, the strengthening of interdisciplinary ties and the expansion of the range of applied research. In the future, it is advisable to expand databases for analysis, include more intersectoral research and develop organizational models that take into account the social and ethical aspects of the introduction of new technologies.

KEYWORDS: Scientific Labour Organization, Remote Sensing, Agriculture, Precision Agriculture, Digitalization Strategy, Automation, Knowledge Economy

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Анализ научной организации труда в исследованиях сельского хозяйства и дистанционного зондирования Земли

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АННОТАЦИЯ

Научная организация труда приобретает особую актуальность в условиях быстро меняющихся требований современного рынка, особенно в контексте растущего взаимодействия человека с роботизированными системами и искусственным интеллектом. Цель данного исследования - провести библиометрический и контент-анализ научной организации труда в сельском хозяйстве с акцентом на интеграцию технологий дистанционного зондирования и точного земледелия. Методологическая основа работы включала библиометрический и контент-анализ научных статей, отобранных из базы Web of Science за период 1992–2025 гг., с использованием кластеризации (CiteSpace 6.3.R1). Результаты показали устойчивый рост публикационной активности: с 2017 года число работ увеличилось до 4 в год, а пик цитируемости пришёлся на 2022 г. Кластерный анализ выявил два доминирующих направления: «Индустрия 4.0» (77 статей, средний год публикации – 2016, S = 0.99) и «Прецизионное сельское хозяйство» (34 статьи, средний год – 2014, S = 1.0). Данные кластеры подчеркнули значение технологических достижений в обеспечении устойчивого землепользования и показали, каким образом инновации в сфере прецизионного земледелия изменяют научную организацию труда и управление сельскохозяйственными предприятиями. Результаты демонстрируют рост интереса к проблематике организации труда в условиях цифровизации агросектора, усиление междисциплинарных связей и расширение спектра прикладных исследований. В будущем целесообразно расширять базы данных для анализа, включать больше межсекторных исследований и разрабатывать организационные модели, учитывающие социальные и этические аспекты внедрения новых технологий.

КЛЮЧЕВЫЕ СЛОВА: научная организация труда, дистанционное зондирование, сельское хозяйство, прецизионное земледелие, стратегия цифровизации, автоматизация, экономика знаний

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INTRODUCTION

The scientific organization of labour refers to the systematic management of tasks, roles, and workflows to enable efficient and effective knowledge production. The concept has its roots in the work of Frederick Taylor (1911), whose theory of scientific management emphasized the scientific selection and training of workers, cooperation between labour and management, and the division of mental and manual work. Later, this direction of study addressed technical modernization, workplace ergonomics, task rationalization, and administrative efficiency, which often lead to substantial labour savings and cost reductions (Freidenzon, 1968). The International Labour Organization emphasises that scientific work organisation not only boosts productivity but also enhances worker well-being and safety (ILO, 2025). Modern applications of scientific labour organization involve collaboration among researchers, technology integration, coordinated data collection, and interdisciplinary knowledge sharing. This approach is particularly vital in technology-driven sectors such as agriculture.

Agriculture plays a vital role in ensuring food security. With the global population steadily increasing, coupled with changing climatic conditions and persistent water scarcity, farmers are at the forefront of tackling today's complex challenges. To improve crop yields and maintain sustainability, the agricultural sector must adopt water-saving technologies and modern management practices that are more efficient. Today, a wide range of innovative technologies supports agricultural resilience and efficiency. These include water-efficient systems, such as sprinklers and drip irrigation, as well as advanced solutions like the Internet of Things (IoT) and space monitoring through remote sensing technologies. The implementation of these technologies is essential for the future of modern agriculture.

Recent scientific advancements have led to the increased use of digital imagery in agricultural research and practice. Multispectral and hyperspectral data captured from satellites and unmanned aerial vehicles (UAVs) are now commonly employed to analyze both field-level conditions and laboratory-based soil samples. This aligns with a broader transition toward conservation-focused agricultural practices, where sustainable land management is enhanced through technology and machine learning (Chaves et al., 2025).

Remote sensing technologies enable the accurate and timely monitoring of surface conditions. These technologies (Satellites, drones, and ground-based sensors) utilize multispectral, hyperspectral, and thermal data to assess the key indicators of crop health, soil status, and environmental change. Portable handheld devices, vehicle-mounted systems, UAV-based sensors, and IoT-integrated platforms enable the detailed monitoring of critical crop traits, including biomass, leaf area index, and nutrient status. While remote sensing holds substantial promise for sustainable agricultural management, its effectiveness depends on the selection of appropriate sensors and the employment of robust data integration methods. (Yang et al., 2025). Moreover, significant challenges remain in terms of scalability, sensor durability, environmental adaptability, and seamless data integration (Wang et al., 2025*)*. Therefore, to meet the new technological needs in agriculture, farmers and other stakeholders should promote knowledge sharing, develop new organizational roles, and promote scientific labour organization.

In parallel with these technological advances, the agricultural sector has increasingly adopted smart farming solutions. Among these, Digital Twins – virtual replicas of physical systems continuously updated with real-time data – offer a powerful approach for simulating, monitoring, and optimizing agricultural processes. This technology enhances decision-making capabilities by providing a dynamic interface for real-time analysis and predictive modelling, supporting precision and sustainable farming strategies (Awais et al., 2025).

Remote sensing technologies have opened new opportunities in the agricultural sector. However, many of these technologies have yet to be widely adopted by farmers because of several challenges. Key barriers include a lack of managerial competencies, limited access to advanced technologies and practical knowledge, and misalignment of mental models and priorities among farmers, policymakers, and researchers.

To fully harness the potential of technological advancements and precision agriculture, there is a pressing need to promote new forms of labour organization and capacity building. This includes fostering collaboration, enhancing digital literacy, and creating an environment that enables innovation adoption among the agricultural workforce. The purpose of this study is to conduct a bibliometric and content analysis of scientific labour organization in agriculture, with a focus on the integration of remote sensing technologies and precision farming. Therefore, a review of the existing literature is of great importance, making this research paper timely and relevant for outlining new directions in the scientific organization of labour in agriculture.

METHODOLOGY

This review analyzed the literature indexed in the Web of Science Core Collection, retrieved in June 2025. Web of Science database was chosen due to its comprehensive coverage of high-quality, peer-reviewed publications across various scientific domains. It is widely recognized by international scholarly community. It also provides comprehensive statistics on publications' search results, making it a suitable database for conducting structured literature reviews and quantitative analysis of research trends. A topic-based query was conducted using the term "scientific labour organization", applied to showcase scholarly works on practices and dynamics of labour organization. This area of study focuses on how scientific work is organized, particularly within interdisciplinary and technologically driven fields.

To narrow the scope and ensure relevance to the precision agriculture, two additional topic filters were applied: "agriculture" and "remote sensing". These terms were selected to focus on studies that examine the role of scientific labour in the context of technology-advanced agricultural practices with involvement of geospatial data collection and analysis.

To ensure the relevance and academic quality of the dataset, the results were limited to publications classified as "Articles" or "Reviews", excluding conference proceedings, editorials, and other non-peer-reviewed content. No restrictions were placed on the publication period, resulting in publications ranging from 1992 to 2025. The filtering process reduced the initial search output of 982 articles to a final dataset of 27 publications, comprising six review articles and 21 original research articles.

This methodological approach ensures that the analysis is based on peer-reviewed, topic relevant literature, enabling a focused examination of how scientific labour organization is conceptualized and studied in the context of precision agriculture.

Bibliometric analysis, conducted using descriptive statistics, was employed to illuminate the field's progression in terms of overall growth (quantitative metrics such as publication and citation counts), its application across diverse research areas, and the identification of key contributors, including leading journals and prominent affiliations. Clustering was performed to identify themes of discussions and research interests using co-citation analysis based on keywords using CiteSpace 6.3.R1. The most frequently cited publications in each year, selected as 1% of the most cited items from each year, created a refined dataset for constructing a synthesized network of references. The evaluation of the network constructed by CiteSpace involved checking the values of network modularity and silhouette values (Chen et al., 2010).

A systematic content analysis was conducted through manual examination of each publication retrieved in the search results. Each publication was carefully reviewed to identify recurring themes and research focus. It allows for examining the content of research discussions objectively. The studies were categorized into three groups to capture different perspectives on the area's development: the earliest works (the three oldest publications from 1992, 2003 and 2009), the most cited works (the top three publications ranked by citation count), and the most recent works (publications from 2021 to present). This categorization enabled a more detailed analysis of the evolution of research discussions over time, while also facilitating the validation of the search results and verification of the quantitative findings obtained during bibliometrics.

RESULTS

Overall growth analysis

The overall growth of a research field provides valuable insights into its development, scholarly attention to particularly research domain, evolving research interest, as well as future potential of a research topic. Growth trends can reveal patterns in scholarly engagement and indicate the increasing relevance of specific topics over time. By examining key indicators such as publication volume, and citation frequency, expansion of research interest in a domain can be assessed. Understanding these dynamics is essential for mapping the trajectory of the field and informing strategic decisions in research planning and funding. Overall growth analysis represents a key component of bibliometrics, which provides quantitative insights into the structure and progression of research domain. A comprehensive analysis of this growth is presented in Figure 1 and discussed in detail below.

Figure 1 presents both bar and line graphs: the bars represent the number of publications from 1992 to 2025, while the line illustrates the annual citation count. Since no specific time range was set in the publication search engine, we can infer that the scientific discussion around labour organization in the agricultural sector is relatively recent.

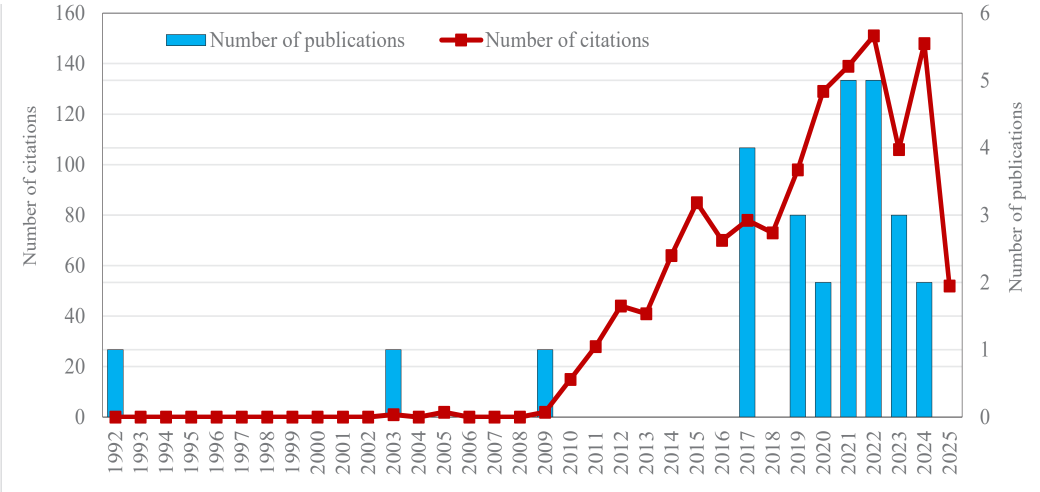

Figure 1. Number of publications and citations for 1992 - 2025

Note: compiled by the authors based on the Web of Science data (Citation Report)

An analysis of the dynamics of publication activity reveals that, until 2016, research on the organisation of scientific work in the agricultural sector was sporadic. Since 2017, a qualitative change has been observed: the number of publications has increased to four, marking a rise in interest from the scientific community in this topic. In 2019-2023, a steady upward trajectory was recorded, accompanied by a significant increase in the number of citations, which indicates the consolidation of the research direction and the expansion of interdisciplinary attention. The peak of citations occurred in 2022, marking a high level of scientific recognition for key publications from this period. The decrease in indicators for 2025 is attributed to the incompleteness of the data, which was uploaded in June 2025, and does not accurately reflect the actual trend of decreasing research activity. The statistical processing is based on the Web of Science database.

Research area analysis

The most prominent research domain is agriculture, which accounts for 15 publications and reflects the primary focus of this study on the agricultural sector. Owing to the interdisciplinary nature of the topic, many of the analyzed publications are indexed under multiple research areas. Beyond Agriculture, the most represented fields include “Business and Economics”, “History”, “Public Environmental Occupational Health”, “Computer Science”, “Geography”, “Science Technology Other Topics”, “Environmental Sciences Ecology”, “Public Administration”, and “Biotechnology Applied Microbiology”. Overall, the topic of scientific labour organization has been examined across a wide range of research domains, as illustrated in Figure 2.

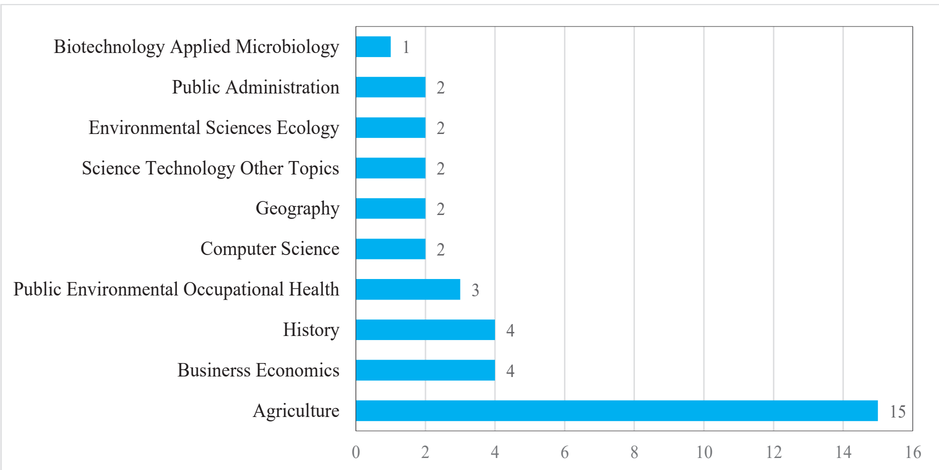

Figure 2. Top 10 research areas of scientific labour organization studies in precision agriculture

Note: compiled by the authors based on Web of Science statistical data (“Analyze Results” tool)

This subsection examines the journals that have made the most significant contributions to the development of the field. Table 1 highlights the top five journals with the highest citation counts related to scientific labour organization in the agricultural sector, reflecting both the impact and sustained scholarly interest in this domain.

Table 1. Top 5 journals with highest citation count in the topic of scientific labour organization in agriculture

Journal	Citation count	CiteScore 2024	Publisher
Field crop research	893	10.7	Elsevier
Computers and electronics in agriculture	115	15.1	Elsevier
Biotechnologie agronomie societe et environment	85	1.6	Les Presses Agronomiques de Gembloux
Journal of rural studies	71	11.3	Elsevier
Agronomy for sustainable development	25	13.7	Springer

Note: compiled by the authors using Web of Science

As can be seen from the data, the most significant number of citations in the field of research on the organization of scientific work in agriculture falls on the journal Field Crops Research (893 citations, CiteScore 2024 – 10.7), published by Elsevier publishing house. Significant contributions are also provided by the publications Computers and Electronics in Agriculture (115 citations, CiteScore – 15.1) and Biotechnologie, Agronomie, Société et Environnement (85 citations, CiteScore – 1.6), the latter of which is published under the auspices of Les Presses Agronomiques de Gembloux. Such publications as the Journal of Rural Studies (71 citations, CiteScore – 11.3) and Agronomy for Sustainable Development (25 citations, CiteScore – 13.7), published by Springer Publishing house, also occupy a significant place.

Table 2 presents the top three journals with the highest number of publications, highlighting the key publishing platforms that drive research output in this area.

Table 2. Top 3 journals with the highest publication count

Journal	Publication count	CiteScore 2024	Publisher
Journal of Rural Studies	2	11.3	Elsevier
Agricultural History Review	2	0.8	British Agricultural History Society
Agricultural and Resource Economics – International Scientific E-journal	4	2.8	Institute of Eastern European Research and Consulting

Note: compiled by the authors using Web of Science

Thus, the analysis reveals that the leading journals accumulating the most significant number of citations on this topic are primarily owned by major international publishers, Elsevier and Springer. This indicates a high level of scientific interest in the problems of labor organization in agriculture and its integration into the global system of academic communications. Leading journals in the field, both by number of citations and number of publications, boast strong CiteScore ratings and are published by well-established, reputable publishers such as Elsevier and Springer. This underscores the quality and significance of the research published in this area.

Table 3 highlights the top 10 institutions that have been instrumental in advancing research on scientific labour organization in the agricultural domain.

Table 3. Top 10 affiliations by number of publications

Affiliation	Number of publications	Percentage of total (n = 27)	Country
INRAE	7	25.926	France
Ministry of Education and Science of Ukraine	3	11.111	Ukraine
Universidade Estadual de Maringa	3	11.111	Brazil
Vetagro Sup	3	11.111	France
Grad Inst Int Dev Studies	2	7.407	Switzerland

Pavlo Tychyna Uman State Pedagogical University	2	7.407	Ukraine
Universite Clermont Auvegne UCA	2	7.407	France
Universite de Montpellier	2	7.407	France
Universite de Toulouse	2	7.407	France
Wageningen University Research	2	7.407	Netherlands

Note: compiled by the authors using Web of Science

Affiliation data were sourced from the results analysis page of the Web of Science database, while information on the countries of these institutions was obtained from their official websites. Regarding the geographic distribution of the top 10 affiliations, five institutions were based in France, two in Ukraine, one in Brazil, one in Switzerland, and one in the Netherlands. As shown in Table 3, Europe leads the advancement of research in this field.

INRAE is France's National Research Institute for Agriculture, Food and Environment, which ranks first in this analysis, with seven publications focused on scientific labor organization in agriculture. A review of key publications reveals that the organization and dynamics of agricultural labour are central to discussions on sustainable farming systems, rural development, and labour markets. Much of this research focuses on labour allocation, employment challenges, evolving work organisation, occupational health and safety, and the socioeconomic contexts that shape agricultural labour – particularly in the work of INRAE researchers (Malanski et al., 2019; Malanski et al., 2021; Malanski et al., 2022). Special attention is given to transformations in agricultural practices, such as agroecological farming and precision livestock systems, which affect labour intensity, foster new forms of cooperation among farmers, and drive the adoption of new technologies (Lucas & Gasselin, 2022; Hostiou et al., 2017). Livestock farming has been studied for its distinct labour demands and broader impacts on rural employment and economic networks (Hostiou et al., 2020). Across Europe, a declining agricultural workforce has sparked concerns over labour renewal and the need for responsive public policies (Hostiou et al., 2020).

Swiss researchers highlight the critical role of international organizations, especially the Food and Agriculture Organization (FAO), in shaping rural development strategies. Their work stresses the historical and ongoing importance of promoting systematic agricultural education and labour-centred rural welfare programs (Forclaz, 2017, 2019).

In Ukraine, researchers have focused on modernizing and rationalizing agricultural practices, with an emphasis on improving labour productivity and economic viability. Their studies explore the integration of social, economic, and technological dimensions through labour organization models, decentralization and innovation in rural entrepreneurship and the development of efficient production technologies and value chains (Rohozha & Svyaschenko, 2024; Sodoma et al., 2022; Svitovyi et al., 2022).

Dutch researchers have examined labour and sustainability challenges in the Global South. They advocate context-sensitive, systems-based approaches tailored to specific ecological and socio-economic conditions, as opposed to universal solutions. Their research underscores the importance of labour organization, resource use, and participatory innovation involving farmers in the design and adaptation of agricultural practices (Giller et al., 2009; Colnago et al., 2021).

Cluster analysis

Cluster analysis was performed using CiteSpace 6.3.R1. displayed the network of 275 references and 25 co-citation clusters. The largest connected components displayed two largest clusters, which account for 40% of the entire network. The modularity of the network equals Q = 0.7739, which is sufficiently high to indicate that the clusters within the network are representative and can be used for further analysis. The weighted mean silhouette value S = 0.9932, which points to a high level of cluster homogeneity. The co-citation analysis consists of the two largest clusters of co-cited references, as presented in Figure 3.

Cluster #0, highlighted in red in Figure 3, boasts the highest number of publications (77 in total). The average publication year of articles from Cluster #0 was 2016. It was labelled Industry 4.0 by publications' keywords and includes key terms such as virtual forest, digital forest, wood supply, and timber. While cluster #4, highlighted in pink in Figure 3, has an average publication year of 2014, which is earlier than cluster #0, it is located after cluster #0 due to the smaller number of articles included in the cluster. In addition to the precision agriculture cluster's label, other key terms of cluster #4 include sensor, robots, automation and labour (see Table 4).

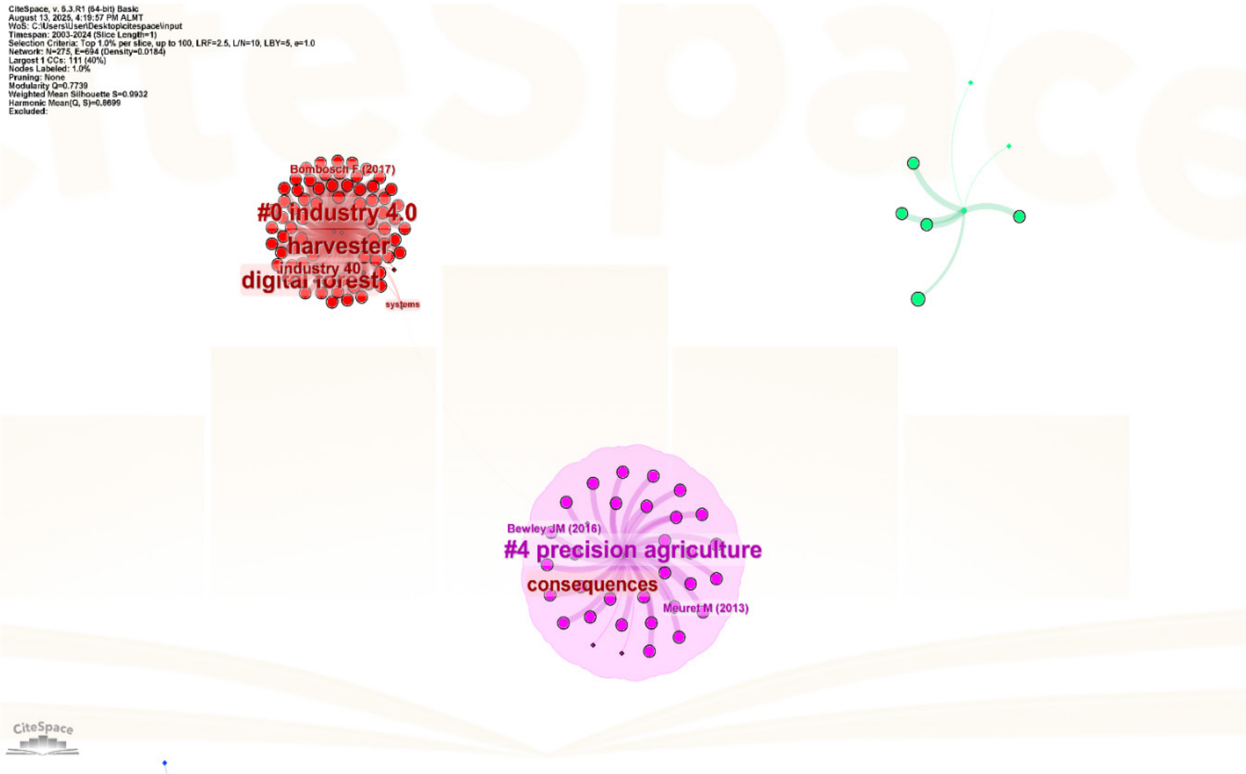

Figure 3. Clusters of co-cited articles

Note: compiled by the authors using CiteSpace 6.3.R1

Table 4. General information on major clusters

Cluster ID	Cluster label	Average year of articles' publication	Number of articles per cluster	Silhouette	Key terms by latent semantic indexing (LSI)
0	Industry 4.0	2016	77	0.99	Industry 4.0; virtual forest; digital forest; wood supply; timber
4	Precision agriculture	2014	34	1.0	Precision agriculture; sensor; robots; automation; labour

Note: compiled by the authors using CiteSpace 6.3.R1

Both clusters have high silhouette values, showcasing a high level of homogeneity – publications are strongly associated with each other in the cluster. They are clearly distinct from publications from different clusters. Clusters were labelled using keywords from the citing articles related to the cluster.

Cluster #0 focuses on technological advancements in sustainable land management. This includes acoustic tools, Global Navigation Satellite System (GNSS) positioning, and remote sensing to enhance forest management and harvesting operations. Acoustic tools enable rapid in-field assessments of wood quality, providing valuable data for optimizing harvest and processing decisions (Walsh et al., 2014). White et al. (2016) reviewed remote sensing methods for facilitating large-scale forest inventories and monitoring. IoT technologies and Industry 4.0 principles, characterized by virtualization, decentralization, and smart data sharing, further support these innovations. These interdisciplinary approaches combine advanced sensing, positioning, and digital technologies to improve sustainable forest management and its operations (Hermann et al., 2016).

Cluster #4 showcases how advancements in precision agriculture and automation have significantly transformed the organization of scientific labour and farm management. The adoption of robots, such as automatic milking systems, has reshaped dairy farming by reducing manual labour demands and introducing new ethical and social dynamics between farmers, animals, and technology (Driessen & Heutinck, 2014; Hansen, 2015). Sensor technologies continuously monitor animal health, behavior, and productivity, thereby enabling real-time data collection and decision support (Rutten et al., 2013; Caja et al., 2016). It not only facilitates more data-driven farm management decisions but also fosters networks of practice among farmers that support experiential learning and technological adaptation (Eastwood et al., 2012). Farmer adoption patterns vary considerably owing to sociocultural factors, individual values, and local labour market conditions, reflecting the diversity of technological integration and its impact on labour organization (Schewe & Stuart, 2014; Borchers & Bewley, 2015). In general, Cluster #4 highlights the complex interplay between automation, sensors, robotics, and the evolving organization of agricultural labour, emphasizing that precision agriculture technologies require not only technical innovation but also social and ethical considerations.

Cluster analysis provides an overview of the research landscape, highlighting two main clusters that illustrate the growth and broad application of the field. Cluster #4 focuses on local farms adopting new technologies and process adjustments through scientific labor organization, whereas Cluster #0 emphasizes the unique opportunities presented by space technology applications. Research on scientific labour organization, agriculture, and remote sensing is still in its early stages but is expanding. In forestry, technologies such as acoustic tools, GNSS, and remote sensing require coordinated efforts among engineers, scientists, managers, and operators to integrate data collection, analysis, and application for decision-making through clear roles and interdisciplinary teamwork. Industry 4.0 and IoT sensor data sharing introduce decentralized, virtualized processes that enable distributed teams and autonomous systems to collaborate via coordinated cyber-physical interactions and networked communication, forming a new model of labour organization (Hermann et al., 2016). Agriculture and forestry IoT platforms show that sharing sensor data across multiple sources demands standardized information management and organizational structures to support efficient data access and stakeholder collaboration, exemplifying labour organization at a systematic level. Future research is likely to evolve through diverse applications across these domains.

Content Analysis

The content analysis of this review delved into the themes discussed within the research area of scientific labour organisation in agriculture. The literature was structured according to the publication period and citation count.

The earliest three research papers in our review were published in 1992, 2003 and 2009, respectively. Hammer (1992) explored the development of institutional frameworks for agricultural labour organizations in Germany. This work represents the first attempt to integrate labour economics and farm advisory services into national policy and research agendas. The importance of international organizations (such as the International Labour Organization) for agricultural modernization is further explored in later research, such as Pan-Montojo et al. (2017).

The publications by Warren et al. (2003) and Giller et al. (2009) draw attention to the socio-ecological and labour challenges in the agricultural sector of African countries. Both publications emphasize the significance of local farming knowledge and labour dynamics in addressing the issues of soil degradation, food insecurity and labour inefficiencies. Warren et al. (2003) highlight the disconnect between external scientific assessments and indigenous knowledge systems, which underscores the need for a more inclusive and adaptive understanding of labour and land-use practices. Giller et al. (2009) critically examined the promotion of conservation agriculture as a solution to these challenges. While widely advocated, this practice has seen limited adoption in countries such as Ghana, South Africa, and Zambia, raising questions about its suitability and the presence of socioeconomic barriers to its implementation.

Citation intensity reflects the degree of recognition and support that a publication receives from the research community. This indicates its contribution to the advancement of contemporary knowledge. In our dataset of 27 publications focusing on scientific labour organization within the agricultural domain, the most cited work is “Conservation agriculture and smallholder farming in Africa: The heretics’ view” by Giller et al. (2009), with 894 citations. This influential publication emphasizes the need for a critical evaluation of the ecological and socio-economic contexts in which conservation agriculture is applied. It questions assumptions about its potential to increase yields, reduce labour requirements, improve soil fertility and reduce erosion.

Another highly cited paper is “Digitization in wood supply - A review on how Industry 4.0 will change the forest value chain” by Muller et al. (2019), with 115 citations. This study identifies general trends towards a smart wood supply chain. Digitalization in forestry ranges from computerized decision-support aids to electronic control and post-harvest management. The article also highlights the latest developments in simulation modelling based on remote sensing data in forestry, laying the groundwork for the concept of a virtual forest as a digital copy of reality. In addition to the technical challenges of digitalization in wood supply, such as robustness, reliability, and accuracy, socio-economic factors should be considered. Among these factors are cooperation, changes in work environments, labour qualification, data autonomy and added value distribution.

Closing the top 3 is "Impact of precision livestock farming on work and human-animal interactions on dairy farms. A review" by Hostiou et al. (2017), with 85 citations. This publication discusses precision livestock farming, which helps with herd monitoring and reduces the drudgery of repetitive tasks. It also focuses on the work organization of dairy farmers and the profession itself.

Current scientific discussions focus on several key topics: the role of international organizations in promoting labour safety, general employment issues in agriculture, and human resource policies that influence labour organization.

International organizations play a vital role in promoting labour safety as part of upholding the social rights of workers. For example, the National Institute for Occupational Safety and Health, through its Agriculture, Forestry, and Fishing Centers, has launched a joint YouTube channel aimed at raising awareness of occupational hazards in these high-risk sectors (Wickman et al., 2021). Similarly, the Inter-Agency Committee on Radiation Safety works across multiple sectors of the economy to promote and harmonize radiation safety standards for workers (Mundigl et al., 2021). Despite these efforts, researchers continue to highlight the lack of access to occupational health services for many workers, including those in the agricultural sector, pointing to the need for worker protection and support (van Dijk & Moti, 2023).

Continuing the discussion on work organization in agriculture, Pashkevich (2024) examined human resource management policies by analyzing indicators, such as labour productivity and workforce activity. One key issue identified is the mismatch between the actual and required number of workers in specific professions in Belarus, highlighting a significant challenge in the implementation of effective personnel policies at the organisational level. In the context of agricultural digitalization, Pashkevich (2024) proposed a system of indicators to monitor staffing and ensure alignment with the evolving demands of the sector. This study identifies key directions for improving personnel policy, particularly through mentorship programs and the development of digital agriculture competencies among employees.

Employment in agriculture remains a pressing issue, with researchers examining not only the social dimensions of employment but also its relationship with the broader production process. For example, Kouakou (2023) analyzed the link between the processing of agricultural raw materials and employment levels in the West African Economic and Monetary Union. The study found that a heavy reliance on the export of unprocessed agricultural products, combined with the massive import of consumer goods and a lack of global competitiveness, contributed to declining employment rates in the region. To address this, the study suggests that accelerating the development of local industries and promoting the domestic production of consumer goods would be effective strategies to boost job creation and strengthen the agricultural sector's role in economic development.

CONCLUSIONS

The integration of agriculture and remote sensing remains a challenging task within scientific labour organizations, despite the critical role that satellite-based technologies play in agricultural monitoring. Remote sensing offers innovative methods for enhancing farm productivity through data-driven decision making. Unlike self-reported agricultural data, which may be affected by intentional misreporting (for example, to reduce tax obligations or attract investment) or unintentional human error, satellite-derived data provide more objective and large-scale insights into agricultural production.

However, the gap between technological advancement and practical application often lies in fragmented cooperation among farmers, scientists, and policymakers. Building effective interdisciplinary communication channels and implementing managerial methodologies are essential for smoother collaboration. In this context, the scientific organization of labour is a critical component in structuring efficient research ecosystems that can bridge interdisciplinary gaps and promote innovation in agricultural monitoring. This review aimed to investigate studies on scientific labour organization in the agricultural sector through bibliometric analysis, with the primary goal of mapping the evolution and current status of this research area.

The review highlighted a steady rise in publications and citations on the scientific organization of labour in precision agriculture, reflecting growing academic interest and the expansion of this multidisciplinary field. Leading publishers such as Elsevier and Springer, along with strong contributions from European institutions, particularly in France, Ukraine, Brazil, Switzerland, and the Netherlands, demonstrated the prominence and quality of research. Cluster analysis revealed two dominant strands of inquiry: one focused on technological adoption and farm-level optimization, and the other on the application of space technologies. Thematic developments showed a shift toward optimizing labour processes and improving working conditions, underscoring agriculture's central role in national well-being. Overall, research increasingly emphasizes the integration of remote sensing technologies and extends the application of scientific labor organization principles to other sectors, advancing labor efficiency and coordinated practices across different fields. This review has some limitations. The analysis was based on a limited dataset, which, on the one hand, suggests the emergence of a relatively new research area and, on the other, may reflect data availability constraints. To overcome this, future research should consider broadening the dataset by incorporating resources from different platforms and employing citation-based expansion methods. Such approaches would not only enhance the coverage of relevant literature but also support the inclusion of interdisciplinary studies and expand the research scope beyond agriculture to other sectors.

In conclusion, this literature review provides valuable insights into the current state and trajectory of research on scientific labour organization and underscores the need for continued scholarly attention and expanded research efforts in this evolving field.

AUTHOR CONTRIBUTIONS

Conceptualization and theory: KK, NB and NZ; research design: KK, NB and NZ; data collection: NZ; analysis and interpretation: NB and NZ; writing draft preparation: KK, NB and NZ; supervision: KK; correction of article: KK, NB and NZ; proofreading and final approval of article: NB. All authors have read and agreed to the published version of this manuscript.

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