International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 3S, 2025
https://www.theaspd.com/ijes.php

The Contribution of Ergonomic Science in Advancing Agricultural Equipment: A Bibliometric Analysis and Literature Review Using VOSviewer

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Abstract

Literature Review this study examines in depth the growing scientific interest in ergonomics approaches. In Indonesia, the majority of the population or people work in the agricultural sector. The application of the work environment and ergonomic machine tools will be massively used to realize a smart farming system (Smart Farming). The purpose of this literature review is to determine the contribution of ergonomics in the development and application of agricultural tools so that agricultural tools can be used according to the specifications and anthropometric needs of farmers. This article reviews 200 articles on Ergonomic Agricultural Tools from Google Scholar and Crossref from 2019-2024, using Publish or Perish and Vosviewer for data visualization. The results obtained are that there is a need for a conceptual discussion regarding the development of technology in ergonomic agricultural tools, realizing a smart farming system (Smart Farming), a discussion about the phenomenon of technological development of agricultural tools that are transforming rapidly and innovatively, and the need to discuss research development or testing. try developing agricultural tools in ergonomics interventions.

Keywords: *Ergonomics, Agricultural Equipment, Systematic Literature Review.*

INTRODUCTION

Agriculture plays a very important role in human survival worldwide (Sambasivam & Opiyo, 2021). In Indonesia, this significance is reflected in the fact that most of the population or community works in this sector (Singh et al., 2023). However, the cultivation and maintenance of agricultural land are still performed manually using traditional labor methods. In fact, the way agricultural land is managed, such as the manual methods, greatly affects harvest yields (Kee, 2022). As the limitations of these traditional approaches become more apparent, the shift towards integrating modern technology becomes increasingly critical. Recent research emphasized that sustainably integrating technology can increase competitiveness and added value (Benos, Tsaopoulos, & Bochtis, 2020; Viana et al., 2021). This technological advancement not only enhances productivity but also contributes to long-term agricultural sustainability.

Today, most of the agricultural technology (especially related to tools and machines) applied in Indonesia is generally imported from other countries (developed countries). While this might be good to ensure its quality, it can also be problematic because the tools are typically designed for the intended country, which in very few conditions are not in accordance with the conditions in Indonesia, for example, in terms of anthropometry, biomechanics, climate and habits, and work culture (Molari dkk., 2019). Yanzina et al. (2019) supported this by stating that the design of a tool made in a country generally uses design parameters appropriate to that country. Incompatibility between a tool or machine and its

user can sometimes lead to minor issues, such as discomfort, but it can also have serious consequences, including accidents or injuries (Mangesh Joshi & Deshpande, 2019).

Given the growing emphasis on modernizing agricultural practices, one important aspect to consider is the application of ergonomics, which significantly enhances the efficiency and safety of agricultural tools and techniques (Okareh, Solomon, & Olawoyin, 2021). For example, in Yogyakarta, Indonesia, farmers using ergonomically designed hoes demonstrated actual work capacities of 60 to 80 percent higher than those using conventional mass-produced hoes. Apart from that, ergonomics is also widely used in managing hydroponic plants, especially for tasks like rice planting. Environmental temperature and humidity must also be considered in accordance with ergonomic principles to meet the needs of agricultural plants (Sakthi Nagaraj, Jeyapaul, & Mathiyazhagan, 2019).

Ergonomics studies the working capabilities and natural limitations of the human body to achieve productivity while maintaining comfort (Lowe, Dempsey, & Jones, 2019). In the context of agriculture, especially in Indonesia, considering environmental ergonomics is crucial. These factors can add value and create a more comfortable working environment for farmers. However, many agricultural activities, particularly in rice cultivation, still rely heavily on conventional, labor-intensive systems that involve manual human-machine interaction (Devanathan dkk., 2020).

Given this situation, it is necessary to develop technological innovations that can enhance these traditional work systems in Indonesia's agricultural sector. Farmers use various tools, equipment, and machines to perform agricultural tasks (Li dkk., 2023). From an ergonomics perspective, these tools must fit the physical characteristics of workers to improve work productivity and safety. Currently, much of the farmers' work in Indonesia is done manually, leading to extended process time, high costs, and frequent complaints (Mishra & Satapathy, 2019).

The machine frame is the most important part of the machine as it serves as the foundation for the installation of other parts including the engine and claw design (Macaulay & Ardley, 2023). To be able to support most of the loads created by the other components associated with the agricultural machinery, the frame must be designed and built solidly. Aesthetics, safety, comfort, and ease of use are some of the considerations that must be taken into account before designing agricultural machinery (Rahman, Yassierli, & Widyanti, 2023). Component safety factors must also be considered, especially in the structure of the machine (Yin & Du, 2021). Load determination is also an important factor that must be considered when designing agricultural machinery. It is crucial to understand the forces acting on the power of agricultural machinery (Scolaro dkk., 2021).

Ergonomics is important for enhancing farmer activities and developing future farming systems (Lohasiriwat & Chaiwong, 2020). As we move towards smart farming, the application of ergonomics will play a significant role in this transformation (Joshi & Deshpande, 2019). The agricultural sector in Indonesia, in particular, has great potential to obtain many benefits from ergonomic interventions. However, these applications are relatively new and few compared to other industrial fields. Therefore, a broader role and intervention in ergonomics is still needed to increase efficiency and productivity in the agricultural sector(Naeini & Z Kaviani, 2020). To address this gap, this literature review aims to explore how ergonomics contributes to the development of agricultural equipment by realizing the latest technology in agriculture. By reviewing existing research, this study seeks to identify areas that scholars have investigated and those that require further development.

MATERIAL AND METHODS

Agriculture is a way or activity to meet and fulfill food needs (Franco dkk., 2020). It involves various activities, such as plowing, fertilizing, irrigating, pest control, monitoring water needs for plants, and regulating soil fertility levels (Feyzi, Navid, & Dianat, 2019). With advancements in technology, modern agriculture has begun to apply precision agriculture (Achour, Ouammi, & Zejli, 2021), a management method that relies on accurate observation and measurement of several agricultural parameters. The results can be used as reference material in carrying out agricultural management quickly and precisely (Akhter & Sofi, 2022).

As a scientific discipline that examines the interaction between humans, systems, and their work environment, ergonomics plays a crucial role in the selection, dissemination, and implementation of

technology (Rodrigues dkk., 2021). Although ergonomics research and applications are generally centered on the industrial sector, its application in agriculture, particularly small-scale farmers, is relatively underexplored. In Indonesia, ergonomic interventions have significant potential to improve agricultural performance (Bezner Kerr dkk., 2022).

An effective agricultural system, or agrosystem, is a complex, integrated network of sub-systems, including on-farm, off-farm, processing, and supporting industries (Chauhan et al., 2019). Understanding these components is essential for improving agricultural practices and implementing ergonomic solutions. One of the most fundamental problems in improving agricultural performance is technology transfer, which is often linked to ergonomic considerations (M Joshi & Deshpande, 2019).

Ergonomics can be defined as the study of human aspects in their work environment in terms of anatomy, physiology, psychology, engineering, management and design (Karwowski & Zhang, 2021). Ergonomics requires the study of systems where humans, work facilities and their environment interact with each other with the main objective of adjusting the work atmosphere with humans. Ergonomics is also known as "Human Factors" (Feyzi, Navid, & Dianat, 2019). The application of ergonomics is generally a design or re-design activity (Mallampalli & Pal, 2021). To improve the capabilities of the human body, several things around the human natural environment such as equipment, physical environment, and motion (work) positions need to be revised or modified or redesigned to suit the capabilities of the human body. The increase in the ability of the human body that occurs optimally, the work tasks performed will also increase (Lu dkk., 2022). Vice versa, if the natural environment around humans is not in accordance with the natural abilities of the human body, it will lead to non-optimal work results (Smith & Jacques, 2022). The science of Work System Design and Ergonomics greatly contributes to efforts to increase productivity at the shopfloor level, increase work safety levels, reduce the likelihood of occupational diseases and reduce the level of emergencies, increase work speed, reduce fatigue due to work, improve the quality of work results, and establish work standards (Pradini, Lucitasari, & Putro, 2019).

This study employed a bibliometric research method, using bibliographic and literature analysis to measure and evaluate the impact, productivity, and relationship among scientific works and their authors. This method helps observe scientific publication trends, identify collaborations among researchers, measure the influence and citation levels of works, and analyze network structures in the scientific literature (Dubyna dkk., 2022). To facilitate this analysis, this study used VOSviewer. This software helps researchers in analyzing and visualizing bibliographic data such as citations, author affiliations, and keywords. VOSviewer enables researchers to create scientific network maps that visually show connections among elements in bibliographic datasets. This visualization helps users identify relevant patterns, clusters, and trends in the scientific literature (Fergnani, 2019). The software allows users to build network maps based on keywords, authors, or institutions and to see the relationships between these elements visually and intuitively. It helps them to recognize clusters of adjacent research, highlight the most influential authors, view collaboration networks among researchers, and analyze changes over time. In addition, VOSviewer also provides various bibliometric metrics such as citation counts, h-index, and keyword frequencies of certain keywords in the dataset (Perianes-Rodriguez, Waltman, & van Eck, 2016).

In addition to bibliometric analysis, this study included a literature review, a systematic and comprehensive research process on existing literature in a specific field of knowledge or topic. The main purpose of the literature review is to identify, evaluate, and synthesize research that has been previously conducted by experts in the field. In a literature review, researchers will search, read, and analyze various sources of information, such as scientific journals, books, theses, dissertations, conference papers, and other relevant publications. This process involves collecting and evaluating data from the literature, such as research findings, methodologies used, and conclusions (El-Halaby, Aboul-Dahab, & Bin Qoud, 2021).

Following that, the study employed the systematic literature review method. Systematic literature review is a term used to refer to a particular study or research methodology and development to collect and evaluate studies related to a specific research topic (Snyder, 2019). The primary purpose is to identify, review, evaluate, and interpret all relevant studies within a particular area of interest with specific relevant study questions. This method aims to characterize and provide an overview of research trends,

methodologies, and coverage in studies related to digital databases of scientific literature in a certain time period (Liu dkk., 2022).

The systematic literature review process can be simplified into several stages and methods.

Table 1. Stages of the systematic literature review process

No	Stages	Objectives
1.	The task involves identifying research questions.	The task involves converting problems into research questions.
2.	Create a systematic literature review protocol.	This document provides guidelines for conducting systematic reviews.
3.	Determine the search area for study results database (e.g., Scopus, Web of Science, Google Scholar, Crossref)	The search area limitations should be defined to ensure the collection of relevant study results.
4.	The study results should be selected as relevant.	The objective is to gather studies that are pertinent to the research questions.
5.	Selecting high-quality study results is crucial for obtaining accurate and reliable information.	The systematic review's quality is assessed using criteria to determine whether or not to include or exclude studies.
6.	The task involves gathering data from individual studies.	The objective is to gather crucial findings from each study.
7.	Synthesize results using meta-analysis (if possible) or narrative methods (if not)	Combine results using meta-analysis techniques (forest plot) or narrative techniques (meta-synthesis)
8.	Present results. Write down the results in a document	Write a report on the results of a systematic review

Source: (Hinderks et al., 2022)

The stages of the systematic literature review process above require the assistance of specialized applications to make the process easier. In this study, the applications used were Publish or Perish and VOSviewer. Both applications are often used for bibliometric analysis (Hinderks dkk., 2022). Publish or Perish is a tool that generates citation metrics from metadata from various indexing databases like Google Scholar, Crossref, Scopus, Web of Science, Microsoft Academic, and Pubmed. It allows users to search for authors, journal names, publication titles, and keywords, as well as to map the range of publication years and citation counts. Meanwhile, VOSviewer is used to visualize bibliographic data, including fields such as titles, authors, and journal names (Al Husaeni & Nandiyanto, 2022). In research, VOSviewer is used for bibliometric analysis to identify research gaps, discover frequently cited references in specific fields, and visualize data clusters.

As argued earlier, this study investigated publications on ergonomic agricultural tools, which were obtained from various sources, such as Google Scholar and Crossref databases. The research process was divided into three main stages to ensure comprehensive data collection and analysis. The metadata for journal articles related to the keyword "Ergonomic Agricultural Tools" was obtained from Google Scholar and Crossref using Publish or Perish. This data was stored in RIS format and analyzed using VOSviewer to create visual representations of the bibliographic data. The findings of this analysis were documented and written in this article.

The second stage involved the expansion of the data sources. Additional journal articles were downloaded from Scopus, Web of Science, Google Scholar, and Crossref by Publish and Perish. This has occurred within this particular stage. RIS format was used again for storage of the data that was collected. Using it, the collected data was stored again. For the sake of consistency, any of the data in Mendeley was converted into RIS format. The data was analyzed using a RIS format obtained from Google Scholars, Crossreff, and Mendeley, using VOSviewer for visual data generation. This certain article then presented all of the analysis's results. In the third stage, the researchers focused on the network analysis of those authors who contributed to Ergonomic Agricultural Tools research from 2019 through 2024. A number of data visualizations, such as thematic categorizations and maps, were produced through this analysis. The data was provided through the size of the circles and through connecting lines by the VOSviewer

output. The size of the VOSViewer analysis results is related to this matter. 2). This paper analyzes document links based on occurrence and strength, using citation analysis to visualize document nature and interlinking through citations. It also tests bibliographic coupling by visualizing and creating networks with shared references, demonstrating the study's closeness based on shared references. The final analysis was co-authorship, analyzing the author's collaboration with other authors and affiliations (Bardini & Di Carlo, 2024). VOSViewer outputs feature network, overlay, and density visualizations, aiding in identifying key trends and relationships in the field.

RESULTS AND DISCUSSION

The study analyzes ergonomic agricultural equipment clusters using journal article metadata from databases like Google Scholar, Crossref, Scopus, and Web of Science, generating visual representations using the VOSviewer application. Table 2 below provides metadata generated from Google Scholar.

Table 2. Metadata from Google Scholar

No	Cites	Per Year	Rank	Authors	Title	Year	Publications	Publisher
1.	163	32.60	113	Lowe, Dempsey, & Jones	Ergonomics assessment methods used by ergonomics professionals	2019	Applied Ergonomics	Elsevier
2.	129	25.80	92	Cremasco, et al.	Risk assessment for musculoskeletal disorders in forestry: A comparison between RULA and REBA in the manual feeding of a wood-chipper	2019	International Journal Environment Research Public Health	MDPI
3.	105	21.00	136	KorhanEnez & Nalbantoğlu	Comparison of ergonomic risk assessment outputs from OWAS and REBA in forestry timber harvesting	2019	International Journal of Industrial Ergonomics	Elsevier
4.	104	34.67	167	Hulshof, et al.	The prevalence of occupational exposure to ergonomic risk	2021	Environment International	Elsevier

					factors: A systematic review and meta-analysis from the WHO/ILO Joint Estimates of the Work-related Burden of Disease and Injury			
5.	101	20.20	48	Joshi & Deshpande	A systematic review of comparative studies on ergonomic assessment techniques	2019	International Journal of Industrial Ergonomics	Elsevier
200	0	0.00	51	Butmee, Intrchom, & Mahaboonpeeti	The effectiveness of ergonomic rice transplanter in reducing awkward posture, physical workload, and working duration among farmers during the manual transplanting process	2024	International Journal of Human Factors and Ergonomics	Inderscience Online

The metadata above was obtained from articles indexed by Google Scholar and published between 2019 and 2024. The process yielded 200 articles, which accumulated a total of 3,099 citations. The data revealed an average of 619.80 citations per year and 15.50 citations per article. The research analyzed articles with h-indices of 28, g-indices of 46, hI norm of 15, annual hI of 3.00, and hA-index of 15, tracing them from Google Scholar. For example, Table 3 summarizes the key findings of articles obtained from Crossref.

Table 3. Metadata from Crossref

No	Cites	Per Year	Rank	Authors	Title	Year	Publications	Publisher
1.	152	30.40	356	Chawade, et al.	High-throughput field-phenotyping tools for plant	2019	Agronomy	MDPI AG

					breeding and precision agriculture			
2.	122	24.40	606	Vieira & Gleason	Plant-parasitic nematode effectors – insights into their diversity and new tools for their identification	2019	Current Opinion in Plant Biology	Elsevier BV
3.	107	35.67	589	Singh et al.	Challenges and opportunities in machine-augmented plant stress Phenotyping	2021	Trends in Plant Science	Elsevier BV
4.	28	5.60	575	De Lucia & Pazienza	Market-based tools for a plastic waste reduction policy in agriculture: A case study in the south of Italy	2019	Journal of Environmental Management	Elsevier BV
5.	14	3.50	91	Sancibrian, et al.	Ergonomic evaluation and performance of a new handle for laparoscopic tools in surgery	2020	Applied Ergonomics	Elsevier
1,000	0	0.00	999	Wirsching & Hofmann	On the progress of knowledge-based motion simulation techniques in ergonomic	2022	Proceedings 7th International Digital Human Modeling Symposium (DHM 2022)	University of Iowa

					vehicle design			

Between 2019 and 2024, Crossref obtained 1000 articles with 2,215 citations, with an average of 443.0 citations per year. Google Scholar had 3,099 citations, while Crossref provided 1,000 articles with 2,215 citations. Metadata from both datasets was saved in RIS file format and analyzed using VOSviewer, resulting in the data displayed.

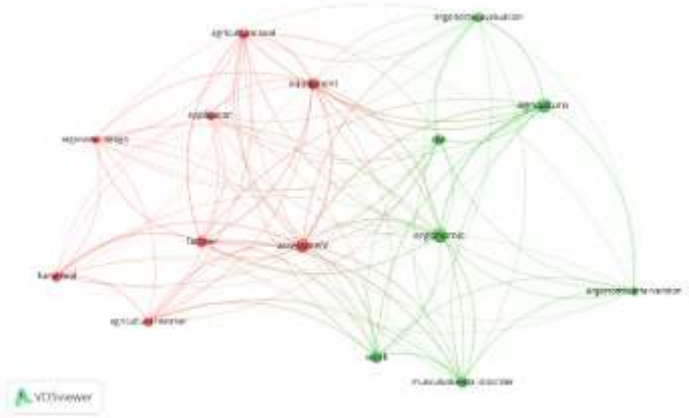

Figure 1. The network visualization results from VOSviewer have been provided

The visualization of relevant keywords related to Ergonomic Agricultural Tools was performed using VOSviewer, resulting in two clusters (green and red) and their explanations in Table 4.

Table 4. Theme Clusters Related to Ergonomic Agricultural Tools

No	Cluster	Included Indicators
1.	Green	Ergonomics, work, musculoskeletal disorders, ergonomic intervention, agriculture, risk, ergonomic evaluation
2.	Red	Assessment, Equipment, Agricultural tools, application, farmer, agricultural worker, ergonomic design, hand tools

Source: Author's compilation

Furthermore, Figure 2 below shows the result of the overlay visualization, which categorizes the articles by their year of publication.

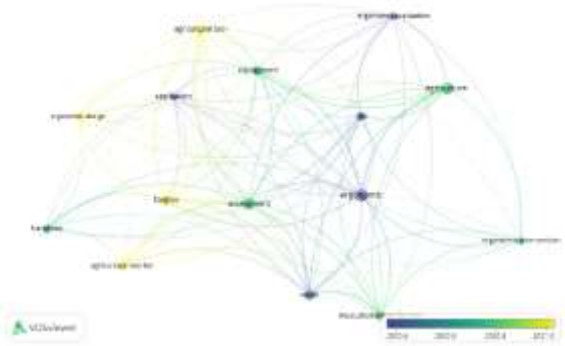

Figure 2. The visualization results from VOSviewer have been overlayed

The visualization shows articles from 2020.4 focusing on ergonomics, risk, and ergonomic evaluation, and 2020.6 focusing on work and application, marked in purple and turquoise green respectively. The year 2020.8 appears in green, with topics including agriculture, ergonomic intervention, musculoskeletal disorder, assessment, equipment, and hand tools. Finally, articles from 2021.0 are visualized in yellow, covering themes such as agricultural tools, farmers, agricultural workers, and ergonomic design.

Following that, Figure 3 below presents a density visualization commonly used to visualize clusters.

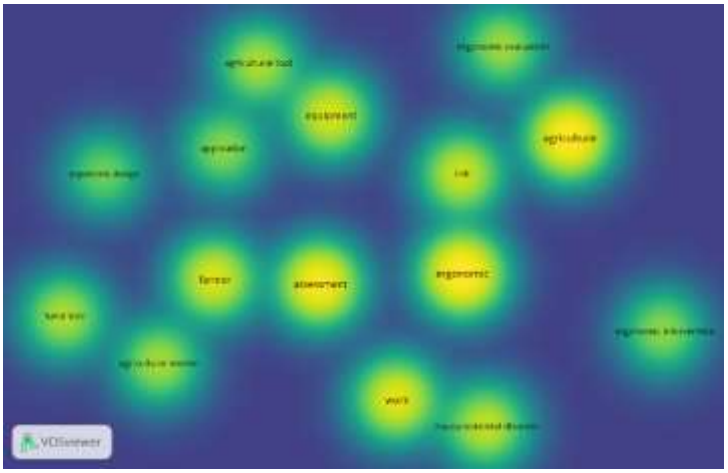

Figure 3. Density visualization results from VOSviewer

The density visualization reveals that keywords displayed in yellow with large circles represent areas that have been frequently researched by scholars. Meanwhile, those in green with circles indicate themes that have not been much researched. This visualization highlights research gaps and suggests that these areas present opportunities for further exploration. To investigate the authors who frequently contribute to the field of Ergonomic Agricultural Equipment, the authors used the VOSviewer application with the option of co-authorship. They obtained the following results, as shown in Figure 4:

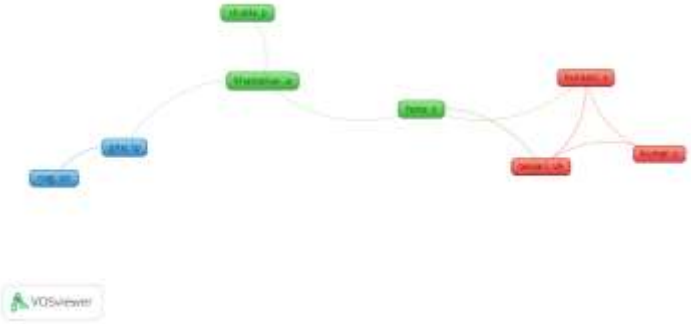

Figure 4. Network visualization co-authorship results from VOSviewer

Figure 5 displays the results of the overlay visualization indicating the connections between authors.

Figure 5. Results of Overlay Visualization of co-authorship from VOSviewer

This overlay result maps the authors contributing to the ergonomic agricultural equipment themes. For instance, in 2020.5, represented in purple, the notable authors are Nag and Gite. Moving to 2021.0, which is depicted in turquoise green, the key author is Hota. By 2021.5, shown in green, Kumari has become prominent. Finally, in 2022.0, highlighted in yellow, the leading authors include Shukla, Khadatkar, Tewari, and Kumar.

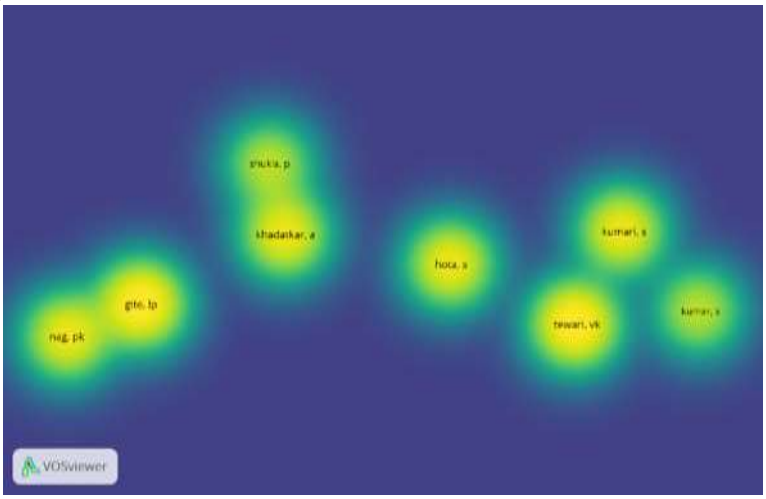

Figure 6. Density visualization co-authorship results from VOSviewer

Table 5. Author clusters for the ergonomic agricultural tools theme

Cluster	Author name	Institution
1	PK Nag	Centered Agriculture: Ergonomics
2	Prabhakar Shukla	International Journal of Occupational Safety and Ergonomics
3	VK Tewari	Ergonomics for Improved Productivity

Source: Author compilation

Table 5 shows a network of authors focusing on ergonomic agricultural tools, mapped based on citations received. The analysis highlights ongoing collaboration and continuity in research related to ergonomics to agricultural tools, with authors on ergonomic agricultural tools themes interconnected.

Having presented the findings from the VOSviewer analyses, the next step is to interpret these results in the context of the broader research landscape. Based on the mapping of publication results regarding ergonomic agricultural tools from 2019-2024, this field has seen a noticeable development. Further analysis shows that research on ergonomics intersects with interventions and contributions, which is proven by the presence of two clusters: Ergonomics and Agricultural Tools. If we look at the research that has been carried out, the ongoing contribution of ergonomics to ergonomic agricultural tools aims to develop and advance the latest technology.

VOSviewer bibliometric mapping illustrates two major clusters: Cluster 1 (marked in green) and Cluster 2 (marked in Red). The network visualization shows a relationship among 15 variables, with 7 variables in cluster 1 and 8 variables in cluster 2. Meanwhile, the results of the overlay visualization show that ergonomics-related research was widely published in 2021 and is closely related to both ergonomics and agricultural tools. Additionally, the results of density visualization indicate a strong thematic focus on the intersection between ergonomics and agricultural tools.

The exploration of ergonomics in agricultural equipment reveals both the novelty and certain limitations. For example, this study highlights how ergonomics themes can stretch very widely and be approached from various perspectives (Kiran dkk., 2024). It is a multidisciplinary and cross-disciplinary science involving agricultural technology sciences (such as work environment, physical conditions/agricultural work aids, mental loads of farmers, and psychological factors of farmers) and general sciences (such as the manufacturing industry sector, psychology, and management). Despite its broad applicability and relevance to ongoing technological advancements, this article only discusses the contribution and applications of ergonomics in the context of agricultural tools.

The study uses Google Scholar and Crossref databases to analyze the advancements in ergonomics' impact on agricultural equipment from 2019 to 2024. The topic of ergonomic agricultural equipment was first discussed by Mario Fargnoli and Mara Lombardi in their 2019 work, "Safety Vision of Agricultural Tractors: An Engineering Perspective Based on Recent Studies (2009–2019)". This year marked the beginning of conceptual studies on ergonomics agricultural tools. With increasingly rapid technological developments, especially in Indonesia, which is popular for its innovations in the agricultural sector, digital ergonomics began to play a crucial role in supporting the food agroindustry work system. This article focuses on ergonomic agricultural tools, indexed in Google Scholar and Crossref databases, despite their widespread coverage in ergonomics books or e-books.

Between 2020 and 2021, there was a surge in interest in conceptual ergonomic agricultural tools, particularly in studies on safety and ergonomics in human-robot interactive agricultural operations. During the global COVID-19 Pandemic, activity restrictions, especially in Indonesia, significantly impacted the agricultural sector so that humans were required to immediately develop new breakthroughs that could ultimately be utilized by humans. One of these breakthroughs in the agricultural sector was the integration of safety protocols, environmental practices, and ergonomic measures involving robotic systems to control all agricultural activities. As society adapted to these changes, the topic of ergonomic agricultural tools also followed the trends by using digital media technologies.

From 2022 to 2023, the focus shifted toward analyzing the use of digital media, such as mobile devices, technology development, and social media. During this period, we also began to discuss the phenomenon of farmer behavior in carrying out agricultural activities. By 2024, research began exploring precision farming systems that employ IoT data analytics, ergonomic interventions for farmers' activities, Smart Farming implementation, risk assessment of farmers' body postures, and the design of agricultural equipment to reduce complaints of musculoskeletal disorders. Studies also delved into prototype development, frequency analysis of agricultural tools, the use of appropriate technology (TTG) by farmers, and the overall effects of ergonomic agricultural tools in minimizing work accidents and reducing excessive complaints.

The narrative mapping from Google Scholar and Crossref datasets highlights potential for innovation in ergonomic agricultural tools, both conceptually and in multidisciplinary sciences. In addition, the development of fast-moving agricultural equipment technology must be accompanied by many ergonomic studies that examine physical, cognitive, and mental aspects, as well as risk assessments related to work accidents. Moreover, the COVID-19 pandemic has also changed farmers' activities and behavior to use ergonomics in agricultural tools. There is also a growing need for developmental studies or trials focused on developing these ergonomic agricultural tools. Exploring this emerging topic will not only strengthen farmers' practices in maintaining work safety but also contribute to understanding how farmers' body posture affects their daily activities as a basis for future studies on agricultural tools.

CONCLUSIONS

A systematic literature review of 200 articles on ergonomic agricultural tools from 2019-2024 was conducted using the Publish or Perish application. The mapping results revealed key clusters of themes related to agricultural equipment, including ergonomics, work, musculoskeletal disorder, ergonomic intervention, agriculture, risk, ergonomic evaluation, assessment, equipment, agricultural tools, application, farmers, agricultural workers, ergonomic design, and hand tools. The topic's novelty lies in the need for a conceptual discussion regarding technological development in ergonomic agricultural tools, the implementation of smart farming systems (Smart Farming), and the rapidly evolving and innovative nature of agricultural tool technology. Moreover, further research should discuss the development and trials of agricultural equipment designed to enhance ergonomics interventions.

Despite these findings, the Systematic Literature Review used in this article presents several limitations in mapping the contribution of ergonomic agricultural tools. One of the examples was the keyword restriction, where only ergonomic agricultural tools were used, which affected the amount of data obtained. Equivalent keywords of "agricultural equipment," such as agricultural tools, ergonomic intervention, application, and equipment, were not explored adequately. Additionally, most articles on the contribution of ergonomics to agricultural equipment are published in English, which limits the

visualization capabilities of VOSviewer. This tool works optimally when mapping metadata from databases like Scopus and Web of Science. However, the analysis in this article does not fully capture trends in the field due to this limitation. Therefore, other bibliometric applications besides VOSviewer are needed, especially those that can better handle and map metadata from simpler or smaller datasets.

ACKNOWLEDGEMENTS
The authors express their gratitude to the Ministry of Education, Culture, Research and Technology of the Republic of Indonesia for supporting educational financing through the 2019 Domestic Postgraduate Education Scholarship.

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