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Review

The Role of Human Resource Management in Agricultural Labor-Saving Technologies: An Integrative Review and Science Mapping

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Abstract: The integrative role of human resource management continues to rise as a topic in sustainable and smart agriculture. This dual focus emphasizes new solutions for agricultural businesses and rural areas, incorporating academic concepts with practical implementations to address the pressing challenges coming from the implementation of labor-saving technologies. The study employs the integrative review method, along with science mapping of literature. After a careful selection of studies from the Scopus database, we included 149 papers for our analysis. Our findings suggest that the overall scholarly work has been concentrated on the topics of entrepreneurship and organizational structure. We conclude that the literature is mostly directed toward sustainability development goals such as gender, diversity, and youth. The current trends topics are "collective action" and "artificial intelligence". Furthermore, our study offered insights into developing and emerging themes, trends, and future directions. The HRM functions that play a pivotal role in the adoption of labor-saving technology adoption are knowledge management, change management, labor allocation, sustainability allocation, and regulatory compliance. Moreover, we provided the practical implementation of the HRM roles and future directions. This study benefits agricultural researchers, agricultural managers, and policymakers because it gives a comprehensive and interdisciplinary perspective.

Keywords: HRM; technology and organization; labor-saving technologies; adoption; integrative review; thematic progress analysis; agriculture

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1. Introduction

In today's knowledge-based society, the importance of human resources is increasing, as a well-motivated workforce with helpful knowledge and skills plays a fundamental role in the economic development of a country and has become a critical factor in its competitiveness. Agriculture remains essential in ensuring food security [1] and achieving various UN Sustainable Development Goals (SDGs) [2]. Despite its importance, agriculture faces challenges such as the social devaluation of farming and rural living, which diminish interest in engaging in agricultural activities. The agriculture sector is characterized by labor-intensive (agricultural workers) and capital-intensive processes (machinery, technology) [3], resulting in high costs for business owners. The introduction of labor-saving technologies such as smart agriculture and robotics can provoke resistance from workers concerned about job losses and motivated by the socio-cultural changes [4]. However, technological advances are recognized as a paradigm shift with the ability to open new paths that promote sustainable and efficient agriculture [5]. For instance, it compensates for seasonal labor shortages

and can improve agricultural production efficiency [6]. Despite these benefits, the aging rural population, rural-to-urban migration, and the declining interest in farming among the young generation are hindering the technology adoption in agriculture. Furthermore, the youth generally lack essential farming knowledge and abilities, further contributing to their lack of interest in farming-related activities. Moreover, this is combined with the lack of support and investment, distancing the younger generation from farming activities [7]. Thus, it is important to assess HR's implications on technology adoption in agricultural firms since it can address the processes of staff recruiting, hiring, training, retention, and remuneration. As pointed out by [8], there is a lack of understanding of the role that human resources play in the adoption of technologies in agriculture enterprises. Therefore, this study provides answers to the following research questions:

(1) What are the trend topics and emerging themes in the field?
(2) How has the thematic progressed during the 2013–2023 period in the field?
(3) What practical recommendations and future research directions can be drawn that can address the role of HRM in the adoption of labor-saving technology in agriculture?

Furthermore, in accordance with our objectives, we have structured our review as follows:

- Section 2 provides a comprehensive review of the literature, research gap, and the expected outcomes;
- Section 3 describes the research strategy process and explains the integrative review method;
- Section 4 comprises broad results and discussions on elements impacting the integration of HRM roles, as well as emerging and trending topics. These are further summarized in the form of a conceptual framework and the practical implications.
- Section 5 states the conclusions, future directions, and limitations of our research.

2. Literature Review

Nowadays, businesses are faced with greater pressure to quickly adjust changing environment [9] of their markets, industry, etc. [10]. Consequently, managers must develop strategic agility [11] through actions and abilities that encourage creativity and capitalize on emerging opportunities [12]. Furthermore, innovation can be positively influenced by organizational learning, and the building elements of organizational learning are human capital, culture, leadership, strategy, structure, and technology [13]. Decentralization is required to achieve this, and the authors' [14] investigation supports that it positively correlates with organizational performance. Furthermore, the authors [15] conclude that cooperate success may be attained if HR professionals accept their roles as talent managers and strategic partners and take an open-minded approach to develop the skills needed for Industry 4.0. However, an organization's competitive advantage is determined in large part by its innovativeness, knowledge management, intellectual capital, and strategic management. Thus, utilizing intellectual resources efficiently and coordinating business plans with innovation initiatives can support long-term competitive success [16]. This is further supported by authors [17] emphasizing the interplay between technological innovation and human development. Integrating technologies in various business operations that involve human resources comes with various benefits and drawbacks. For instance, employing data analytics to make well-informed decisions regarding talent acquisition and leveraging technology to streamline recruiting procedures [18]. Additionally, adopting cloud-based platforms and modernizing HR systems in order can improve productivity and efficiency in agriculture [19]. Moreover, up-skilling staff to accommodate job positions and technological advancements can help in retaining suitable employees [20]. Meanwhile, the organization's goals in regard to diversity, equity, and inclusion while managing employees can be a challenging task for HR professionals [21]. The agricultural labor itself is driven by the market of the future. The uncertainties coming from technological advancements, such as the reduction of manual labor directed toward technology-oriented personnel, require new regulations and laws to be designed [22]. Modern technologies (labor-saving technologies

in agriculture) that are rapidly developing, such as artificial intelligence and precision farming, require farmers to reconsider the farming style and staff they select in their daily business activities. Furthermore, the concept of knowledge management is becoming increasingly popular in all sectors of the global economy because of its enhanced importance in facilitating the creation, codification, preservation, and transfer of knowledge, and its ability to significantly improve an organization's knowledge capital.

At the farm level, introducing new technologies leads to a reallocation of activities and resources, while the need to develop new technologies leads to developing new skills and competencies [23]. Low technology adoption rates have long been a significant factor hindering improvements in agricultural productivity, income, and yields, especially in developing countries where market-based production systems are underdeveloped and subsistence economies remain strong [7]. The dynamic context, complexity, and local specificities of current challenges facing agriculture, such as climate change, food security, and resource depletion, and the multiple roles expected of agriculture require a more inclusive, flexible way of managing knowledge creation, integration, and sharing [22]. The success of agriculture depends on the quality of knowledge that is applied to increase crop yields. Farmers' entrepreneurial and organizational competencies are crucial for increasing household food and income security and shaping sustainable agricultural development. An effective knowledge management process strengthens the whole chain of agricultural activities [24,25]. Universities are among the institutions tasked with building these competencies. Higher education institutions have become perhaps the most critical actors in regional development in the first decades of the 21st century. Without the proper and effective involvement of universities, it is difficult to imagine the development of regionally-based economic development or innovation. The success and performance of the collaboration between higher education and regional government [26] can fundamentally determine a region's competitiveness [27], economic performance, and opportunities for social well-being [28].

Study [29] classifies barriers to knowledge transfer into three groups: economic, institutional, and social factors. Economic barriers include an inadequately skilled labor force and a lack of political and financial support. Institutional factors reflect some of the challenges farmers face in using ICT, such as the lack of tools to access the internet, constraints on the affordability of ICT tools, and lack of knowledge and time. Socio-economic and demographic factors include age, marital status, household size, educational attainment, land size, farming experience, participation in non-farming activities, credit borrowing, and Information and Communication Technology (ICT) experience [29].

Education contributes to developing farmers' ability to acquire, decode, and understand information. Educated farmers have better decision-making skills and, thus, better resource management. Findings drawn in the study [30] suggest that better-educated farmers are quicker to adopt—and even seek—new technologies can distinguish between promising and unpromising innovations and are willing to try riskier production technologies in the hope of higher returns. However, farmers with no or lower skills are more resistant to new technologies, typically not adopting a new technology until its benefits are known or waiting until their peers have successfully adopted it [30]. As the technology used by agriculture is constantly evolving, the education system must also be responsive to the changing needs of agriculture. The agriculture of the future needs well-educated professionals with technical, IT, tax, and business skills and good communication skills. One of the keys to success is reaching farmers with the right agricultural information at the right time and on the right platform.

Socio-economic demands on universities mean that the transfer of knowledge and technology created in universities is becoming increasingly important in addition to their traditional mission. Less attention has been paid to identifying and analyzing the strategies universities employ in knowledge management. The link between university and economy improves the quality of university education and research and increases graduates' employability by equipping them with skills and knowledge valued by the economy. With its

basic training of scientists, the university system is responsible for bringing technological knowledge into the economy (industry, agriculture). The knowledge and skills of the employees employed by agricultural enterprises are crucial when management wants to increase production, efficiency, and profits. This knowledge transfer is essential to foster innovation, entrepreneurship, and economic growth. Universities can access resources, expertise, and funding that are essential for research and developing new technologies. This collaborative approach allows universities to contribute to developing technology and scientific infrastructure, which in turn supports economic growth. Knowledge management, in this case, refers to the transfer of knowledge from higher education institutions of society and organizations and to a wide range of activities aimed at promoting entrepreneurship, innovation, social welfare, and human capital development. The term "agricultural technology transfer" describes the process of formal transfer of new technologies. Agricultural discoveries, improved practices, or innovations from research institutions are used to transfer technology to the farming sector [31].

One of the keys to success is getting the correct agricultural information to stakeholders at the right time and on the right platform. As concluded from [22], this can be a result of the transition towards more sustainable agriculture requires a new knowledge base, with new content and forms of knowledge and new learning processes. Less experienced or aging farmers may more often resist knowledge imparted through traditional education [22]. For this target group, universities can provide informal rather than formal education to transfer new technologies and expertise [30]. This may include the third mission of universities, where the university organizes sales, meetings, and workshops outside the walls of the higher education institution, mainly for non-educational participants, the form of sales, seminars, and workshops that are accessible to the general public but also present the latest technological developments [32]. Informal knowledge refers to the various forms of knowledge outside the formal agricultural knowledge system, created by professionals based on their own experience, without externally imposed criteria. The confluence of academic and field experiences enriches the development of technology adoption. Another vital knowledge transfer instrument of agricultural policy (besides higher education) is the extension of agricultural extension activities, especially in rural areas. This activity acts as a link between farmers and researchers, facilitating the sharing of innovations [22]. Agricultural advisory services are key to informing and influencing decisions on rural farms, especially in developing countries, which generally have a greater need for such services [33]. Agricultural extension services can disseminate agricultural knowledge through on-site demonstration and pedagogy and potentially translate it into terms and processes more appropriate to the local context—cultural and agroecological. At the same time, they can provide valuable feedback and, sometimes, helpful financial resources to research and extension agencies [34], found that the involvement of local farmers as stakeholders increases satisfaction and commitment to adopting new technologies [35]. Moreover, as highlighted by the study [24], the tension with new technologies is related to the extent to which the proposed innovations and technologies require some level of change in smallholders' values, practices, and long-standing, culturally accepted patterns of behavior. HRM is successful when the transfer of knowledge, by transmitting the insights of experienced farmers, is also transferable to scientific findings and adapted to the specific structure of local communities [22].

Figure 1 illustrates the research gap identified in the four pillars of the knowledge-based model: institutional framework and economic incentives, skilled and educated workforce, effective innovation system, and sufficient modern infrastructure [36]. We expect that "the integration of HRM functions with labor-saving technologies positively impacts the productivity and efficiency in agricultural business operations".

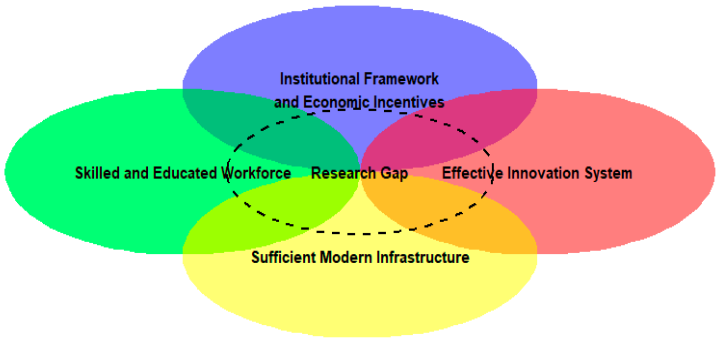

Figure 1. Research gap in the knowledge-based model. Source: Authors' construction.

3. Materials and Methodology

3.1. Materials

We used the literature obtained from the Scopus database (www.scopus.com accessed on 26 March 2024–1 April 2024), which is a reliable source for scientific-specific and/or multidisciplinary studies [37]. The main search query to retrieve the data was TITLE-ABS-KEY ("technology adoption" AND "human resources" OR "human resource management" OR "hr" OR "hrm" OR "agricultural labor" OR "agriculture workforce" OR "agricultural employment" (the study began in September 2023, and then further refined during 26 March–1 April 2024)). Furthermore, for this study, the workflow of the searching process, inclusion, and exclusion have been recorded following the updated version of PRISMA guidelines [38]. We included only the English language literature, and excluded 3 studies published in Chinese language, 2 papers in Spanish, and 1 paper in Japanese. Furthermore, we excluded 3 book chapters and 4 short surveys. This is further detailed information is given in Appendix A. Finally, we ended up with 187 documents after the English language criteria. After applying the inclusion and exclusion criteria, we ended up with 149 documents: 129 articles, 15 conference papers, and 5 review papers (Figure 2 outlines the research workflow in detail).

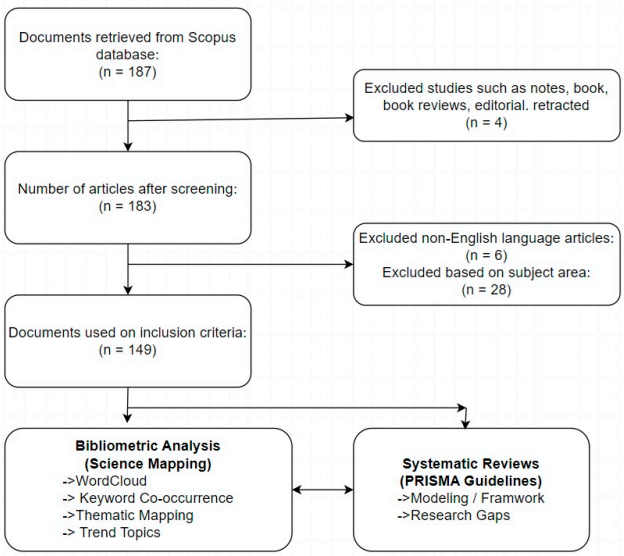

Figure 2. The research process following the PRISMA guidelines. Source: Authors' work.

3.2. Methodology

The integrative review method developed by [39] was chosen to thoroughly critique and synthesize the representative scattered literature in an integrated way to generate new perspectives and frameworks on the complex topic of the role that human resources have in adopting agricultural technologies. Recently, the integrative review method has been

applied in business fields to address complex challenges. For instance, it has been used to model frameworks that address demands, resources, and stressors by identifying and categorizing factors affecting job performance [40]. In addition, the authors [41] have used the integrative method to propose a model explaining how the work–life balance enhances life satisfaction by exploring the psychological and social processes involved. Therefore, the integrative method is well-suited for addressing the complex nature of agricultural technology adoption and human resources since it allows for the integration of findings from diverse perspectives [42,43] of HR strategy innovations, as well as research on leadership style, workforce diversity, and organizational values. *Strengths:* Some of the advantages that integrative reviews offer are effective identification of gaps and emerging topics in existing literature with overlooked connections and insights, methodological flexibility, and ease of adapting to various research questions and types of data. Additionally, it is the only method that permits the combination of studies with diverse methodologies, as such providing abroad evidence-based summary and actionable recommendations [44]. *Limitations:* Although there have been advancements to improve the approaches to the data collected and extracted for integrative reviews, the processes for analyzing, synthesizing, and drawing conclusions from this data are still not clearly established [39]. As such, a bibliometric analysis was performed for data evaluation to allow the identification of key themes, emerging trends, and areas of high impact in the qualitative and quantitative dimensions of the topic. We used the Bibliometrix package, which was created by authors [45] based on the R programming language, which provides an evaluation of scholarly performance, trend topics, co-occurrence, thematic mapping based on citations, countries, authors' keywords, keywords plus, etc. [46]. In addition, the 7-S McKinsey framework developed by [47] was used to summarize the interdependent nature of the structure, strategies, systems, skills, staff, and shared values discussed in the literature. The technique helps mitigate shifts and problems associated with introducing labor-saving technology in agriculture and provides a more strategic organizational design (a graph was visualized using Draw.io: https://app.diagrams.net/ accessed on 1 April 2024).

4. Results and Discussions

The results and discussion sections are arranged in the following manner: Section 4.1 provides an overview of the scientific publication performance over the years. Followed by a contextual word cloud and overlapping of the keywords in Section 4.2. Furthermore, Section 4.3 describes the trend topics and thematic map. Additionally, Section 4.4 examines the themes' relevancy and level of development of the integrative role of HRM.

4.1. Annual Scientific Production

Figure 3 exhibits the scientific research output, featuring a y-axis reflecting the number of articles published and an x-axis demonstrating the years 2013–2023. The lowest number of academic works on the subject, with 7, 4, 5, and 6 papers, respectively, were conducted in the period 2013–2016. A steady increase in scientific production is identified during the years 2017 and 2018 with the same pattern (10 publications). The increasing trend continues in the years 2020 and 2021, with 18 and 24 publications, respectively. Meanwhile, a slight decline was recorded in 2022 (23 publications). Furthermore, 2023 was noted as the year with the majority of the scientific publications (27 papers). Overall, the number of articles published each year has increased over time. In addition, with the help of the fitted linear model: article (y) = 2.38 $\times$ * year (x) + intercept (Figure 3), we determined the average rate of increase (articles/year). According to the linear model, the average rate of rise in publication is 2.38 articles per year; this is an important finding because it implies that there is a continually growing interest in the topic.

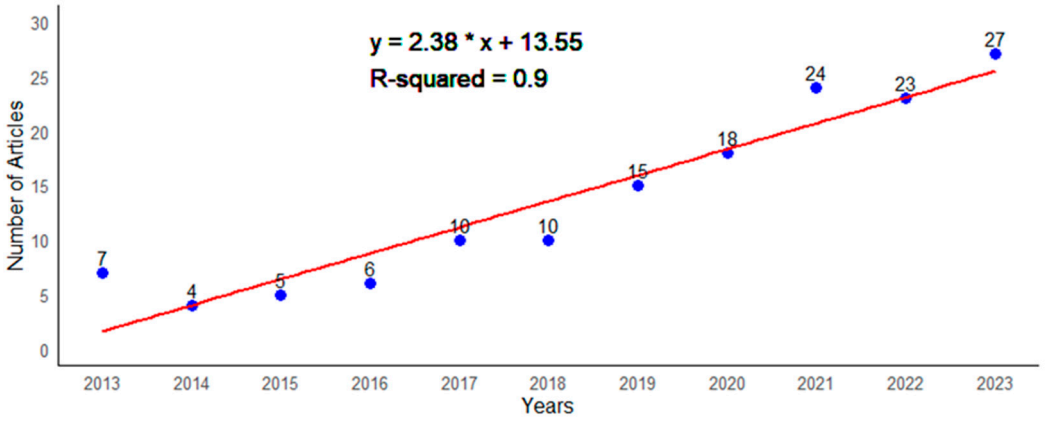

Figure 3. Annual Scientific Production (2013–2023). Source: Authors' work.

4.2. A Contextual Word Cloud and Overlapping of Keywords

In addition, a word cloud (Figure 4) was created with the help of the Bibliometrix package [45]. The contextual word cloud displays the most frequently used terms used by authors in the literature. The keywords of "innovation", "labor market", "agriculture", "agriculture labor", "technological development", "artificial intelligence", "behavioral research", and "information and communication technology" were most commonly used by scholars suggesting an interest towards technologies that facilitate the agricultural processes and daily activities. Furthermore, the term "behavioral research" indicates that scholars have been investigating the farmers and agriculture workers in connection with the adoption of agricultural innovations. The aspects of "organizational framework" and "engineering education", "research and development", and "workplace" have been explored.

Figure 4. Word Cloud. Source: Authors' work.

Figure 5 depicts the overlapping of the terms displayed in the word cloud as a co-occurrence network, which provides a more thorough view of the topic. The Louvain algorithm was selected to visualize the network into hierarchical groups, which groups the keywords based on similar attributes. The size of nodes represents the frequency of the keyword in the dataset, and the color of the nodes signifies distinct groupings, emphasizing various points of interest throughout the topic. In total, four groups were identified:

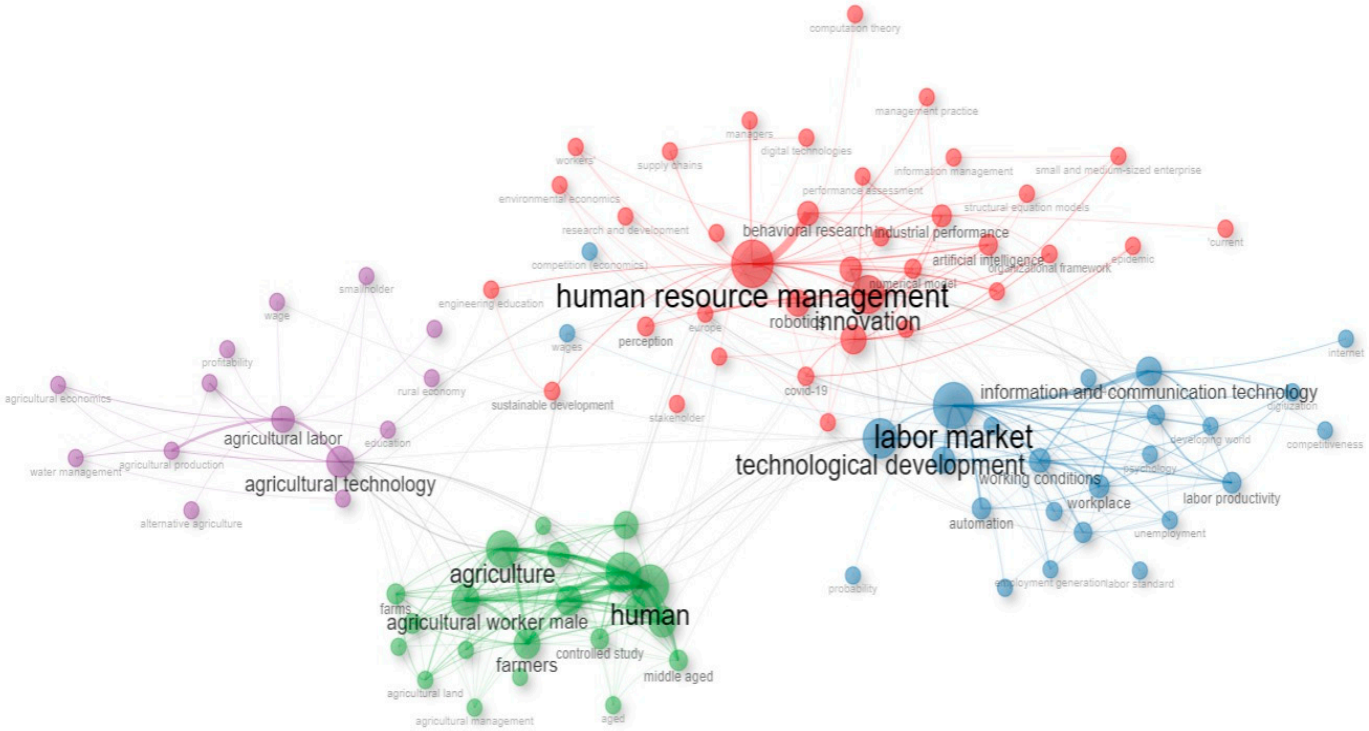

Figure 5. Keyword Co-occurrence Network. Source: Authors' work.

The red color cluster is the largest cluster with the main keywords "human resource management" and "innovation". The cluster indicates that scholars have been working on strategies that optimize the human capital of the organizations since it can ensure more competitiveness in the agriculture sector [48]. Thus, the cluster further establishes the human resources' role in the workplace and the implementation of labor-saving technologies in the organization's daily activities.

The blue cluster provides insights into how authors have examined "technological development". This cluster indicates that the scientific works have analyzed the perspective of the workforce structure from the employment patterns and skills requirements to job opportunities in connection with the "labor market" [49].

The green cluster visualizes the complex relationship that characterizes farm management in developed and developing countries [50] from "agriculture", "human", "agricultural technologies", and "age farmers" aspects. Moreover, keywords such as "middle-aged" and "age farmers" indicate that scholars have explored the role of social-demographical factors in effectively managing technologies as a whole [51].

The purple cluster is the networking of the main keywords "agricultural labor" and "agricultural technology", highlighting the rapid progress of technological breakthroughs in mechanization and automation, which have consequences for labor practices and employment in the agriculture sector [52].

4.3. Trend Topics and Thematic Mapping

Figure 6 displays the trend topics between 2013 and 2023. During 2023, researchers appear to have been interested in the "effect" agricultural technologies have on employment and the "source allocation" of human resources in agricultural firms. Meanwhile, in 2014, experts concentrated on the potential for "economic growth" that was brought up by innovation. Furthermore, in 2014, the topic "curriculum", which belongs to education, was examined with the purpose of accommodating the supply and demands of agricultural labor. Meanwhile, "social capital" emerged as a research trend in 2015 since it drives improvement in the adoption of agriculture management practices [53]. The term "social change" gained popularity in 2015 and it coincides with difficulties faced by agricultural

firms to successfully implement labor-saving technologies. Additionally, in 2016, academics appeared to have been interested in investigating possibilities for "off-farm employment" affects beyond traditional farming. In 2016, scholarly work was centered on issues and technological innovations in "developing countries". The discussion of how "cultural influence" multiple facets associated with agricultural adoption in decision making processes, along with the examination of different "governance" structures, were prominent themes of 2017. The themes of "efficiency" (an assessment of the technical efficiency of agricultural labor) and "gender roles" in the agricultural sector appear as trends in 2018. Throughout 2019, there was a shift heading towards "education" and "empowerment" topics. Meanwhile, in 2020, scholars looked at the level of earnings obtained by workers as "wage" and "working conditions". The topics "occupation" and "algorithm" linked with jobs and professions emerged as trends in 2021. In 2022, the keyword "competitive" suggests that researchers primarily focused on the variables that drive the competitiveness of agricultural enterprises in the agricultural sectors. Throughout 2022, the attention of scholars was concentrated on "livelihood reconstruction ". Lastly, the switch to "artificial intelligence" and "collective action" in 2013 reflects the current trends in technological advancement and social organization linked with the adoption of labor-saving technologies.

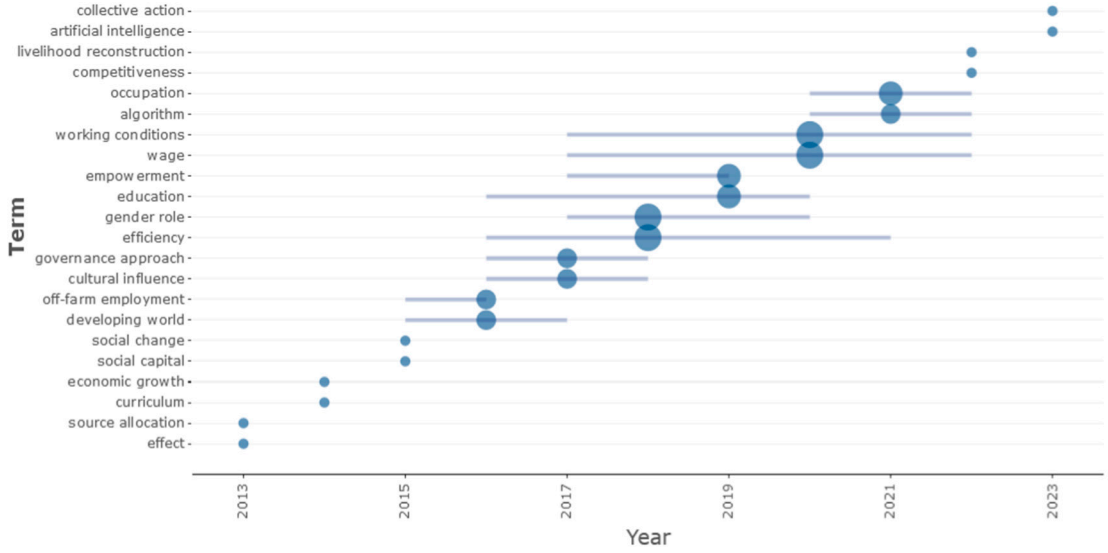

Figure 6. Research trend topics. Source: Authors' work.

In addition, the thematic map for the period 2013–2023 (Figure 7) was created to distribute the topics into four quadrants: basic themes, motor themes, niche themes, and emerging/declining themes based on their level of development and relevance degree. The size of the cluster indicates the concentration of the scholarly work made by academics [45].

Motor themes (well-developed themes): The motor themes of the topic are "gender, entrepreneurship" and "demography, labor force".

Basic themes (developing themes): "Immigration, agricultural workers" and "agricultural sector, competitiveness" are currently of interest to scholars.

Niche themes: Specific themes such as "elasticity of substitution, age structure", "gender and diversity-youth", and "structural transformation, agricultural productivity" appear to have been actively researched.

Emerging/Declining themes: "Labor market "and human resource management", with high relevance for the topics, have been declining. Meanwhile, "agricultural labor productivity, complex mechanization", and "migration and employment" have been emerging as topics.

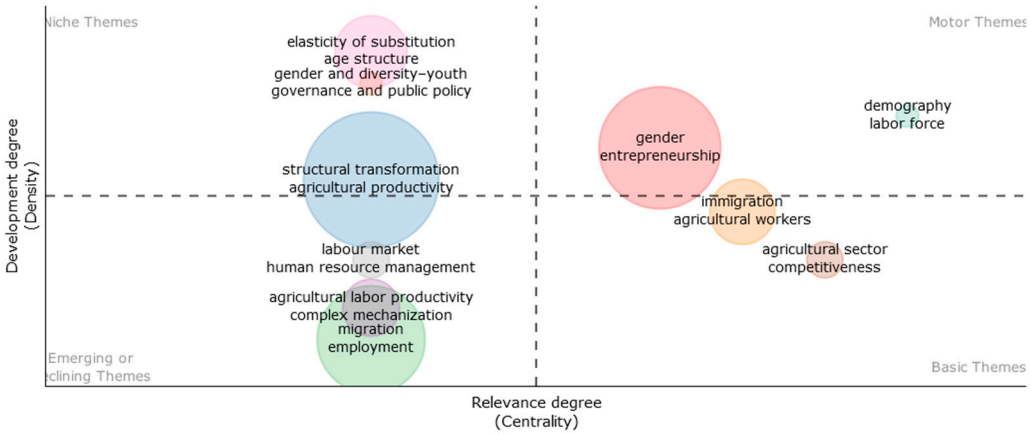

Figure 7. Thematic Map of the period 2013–2023. Source: Authors' work.

4.4. Thematic Progression Analysis

This Section provides in-depth analyses of the development and the relevance degree of the thematic progression described in Figures 3–5 and 7. Furthermore, we summarized the progress of scholarly work, and we presented the 149 papers in a conceptual framework (Figure 8). The figure outlines the interconnectedness of the HRM topics in two main categories: Factors influenced by management (structure, strategy, and systems) and factors influenced by corporate culture changes (skills, staff, and style).

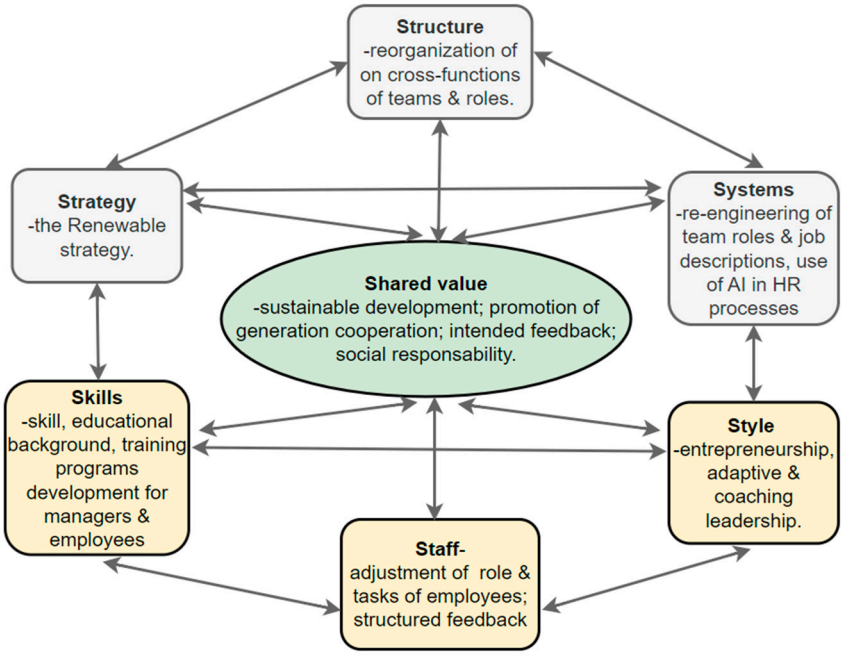

Figure 8. Proposed framework based on 7-S McKinsey analysis. Source: Authors' construction.

4.4.1. Factors Influenced by Management (Structure, Strategy, and Systems)

The topics associated with "demography and labor" have not been thoroughly explored and seem to have lost relevance in the last decade of scholarly work, despite the fact that technological type, cultural context, and geographical location are determinants for successful implementation [54]. This can be explained by the shift of scholarly interest towards sustainability development goals, which is further supported by the findings of [55]. Meanwhile, farmers are more ready to adopt SFT in comparison with extension workers but have lower readiness, and this is attributed to the limited capacity (economic and technical aspects) [56]. The results of the study [57] indicate that educated farmers

are more likely to adapt to new agricultural technologies, with an increased likelihood of 3.37%. Despite this, the performance of females is hindered by fewer learning opportunities, leading to a lower impact of self-learning in subsequent periods [58]. The "collective action" has been a popular topic among researchers because of its potential in mitigating the challenges of education and training, which contradicts the findings of [59]. The study concludes [59] that agricultural cooperative structures are too complex and not flexible enough to adjust changes in operations. Organizational commitment and engagement have a partial mediating effect on the relationship between HR practices and turnover intention [60]. Furthermore, as highlighted by [61] , online technologies offer learning and education, particularly for women.

4.4.2. Factors Influenced by Corporate Culture (Skills, Staff, Style)

Developing themes: The cluster of "gender, entrepreneurship" (Figures 6 and 7) has been well explored by scholars. Evidence [62] suggests that new entrants into agriculture have a stronger entrepreneurial orientation than the established ones, but also, an agricultural entrepreneur lacks entrepreneurial capabilities compared to other sectors. This challenge is important challenge to address since the limited knowledge and entrepreneurial behavior among new entrants [62] can have a significant in the competitiveness of agricultural firms in modern agriculture. This is further supported by [63], in which the role of women is at the forefront of implementing innovative practices and/or ideas to foster a more entrepreneurial mindset, which is critical for adaption and flexibility within the farm. Moreover, as highlighted by [64], embracing ICT usage among women micro-entrepreneurs helps them better adapt the new technologies and achieve their entrepreneurial ambitions. Although the advance in agriculture increases agricultural production and facilitates economic growth [65], it also has an impact on the "structural transformation" of labor demand. According to [66], land tenure was the most significant factor in promoting structural transformation and sustainable development. Scholars appear to ignore the exploration of these barriers.

Meanwhile, study [67] highlights that farm size and intensity, access to credit, and agricultural education foster innovation while increasing age and working off-farm hinder innovation. But, the family's training and human capital, successful implementation of innovations, effective time and organizational management, business planning, and the farms' special environmental conditions had a favorable impact on farm performance [68]. Further navigation in implementation costs is required in reorganizing the workforce and assigning jobs, responsibilities, retailing talents, and considering the training and education since it can impact the business performance [69]. The study's findings [70] indicate that female plot managers experience a 23.1% disadvantage due to structural constraints (access to resources, societal norms, policies), which must be taken into consideration while developing policies. The organization has to foster the value of stakeholder cooperation and the development of an innovative, inclusive, and continuous improvement culture, as stated by [35].

Emerging themes: Labor remains the most important factor in agricultural output at present; increasing technical innovation and capital investment can further enhance productivity and address issues in the agricultural sector [71]. Understanding the sectorial differences can increase firm efficiency [64], and the adoption of sustainable agricultural practices has been shown to contribute to agricultural labor productivity [72]. Various demographic and skill-related characteristics, such as education, age, skill, training, gender, and cooperative support for technology adoption, appear to influence agricultural revenue [66]; this is contradicted by the study findings [73]. The authors [73] argue that the sector the firm operates influences "age" productivity rather than region. Younger farmers are shown to be handling larger farm operations, employing more labor, and yielding greater value from their endeavors [74]. Furthermore, women in developing countries compose 13% of the agricultural workforce and have a significant role in wage labor but are additionally less active in commercial and contract farming [75]. Cooperative member-

ship has shown the potential to increase women's influence and decision-making abilities, according to [76].

Furthermore, it is important to evaluate strategies that improve HR readiness with the aim of benefiting from new opportunities arising from business process digitalization and new technologies [77] and organizational resilience [78]. In addition, the introduction of new technologies, such as big data, machine learning (ML), IoTs, and digital twins, can help businesses benefit from financing, commercialization, operations and logistics, traceability, and insurance opportunities, as highlighted by [79]. Through the lens of the aforementioned, agribusinesses must examine the capabilities that accompany strategic renewal processes [78,80]. The main capabilities of strategic renewal processes in human capital consist of adapting processes (modifying and upgrading human capital), adapting structures (restructuring teams, redesigning operational processes), and responsiveness (capitalizing on new opportunities) [80]. Furthermore, the categorization of the role of HRM has on technology adoption in agriculture with its corresponding HRM functions are provided in Table 1 as practical implications of this study.

Table 1. Practical implications: the functions and the role of HRM. Source: Authors' work.

Main HRM Functions	The Role of HRM on Technology Adoption in Agriculture:
Technology training and development	-Enables training for employees on how to utilize modern machinery before going to a job [81]. -Offers opportunities for personal development [22].
Change Management	-Supports farm managers and agriculture workers to ensure smooth transitions [23]. -Addresses the resistance to change [82].
Labor Allocation	-Adjusts the roles (responsibilities) and tasks for employees and matches their capabilities on farm activities [83].
Sustainability Allocation	-Improves resource efficiency by setting up adequate teams [84]. -Aligns and coordinates the values of the organization's principles with the sustainability goals (SDGs) [85]. -Improves and attracts the new generation into agriculture farm activities [86,87] driven by technology changes (ensures generation cooperation) [88].
Regulatory Compliance	-Adapts and enforces technology practices [89] in compliance with current laws and regulations [90], such as cybersecurity concerns and data management concerns [18,91].
Knowledge Management	-Provides adequate education matched with the new technological skill requirements [92–94]. -Opens new jobs and/or builds new job profiles that match the workers' attitude (attitude hiring) [95,96]. -Facilitates and ensures adequate recruitment aligned with educational background [97]. -Develops workforce restructuring: the company addresses the challenges caused by job hoppers and ambitious people [98] by offering personal development. -Collects and assesses the intended feedback in relation to new employees (adjustment process), employee performance, and challenges coming from the teams in regard to technology adoption [99].

The expected result, "The integration of HRM functions with labor-saving technologies positively impacts the productivity and efficiency in agricultural business operations", is proved to be partially true by the literature, which suggests that HRM has an important role in knowledge management and change management functions, and other functions such as technology, training and development, labor allocation, sustainability allocation, and regulatory compliance. HRM functions of sustainability allocation and technology, training, and development have been thoroughly investigated in the literature.

5. Conclusions

We conclude that the scientific work on the topic shows a constant increase in the last decade (2013–2023). Our findings suggest that the topics of entrepreneurship development, organizational structural transformation, and overall the impact of agricultural productivity aspects are continuing to be explored and with high interest for academics. Meanwhile,

gender, diversity, and youth engagement are emerging as themes, with particular focus on educational (SDG4), gender equality (SDG 5), and inequality reduction (SDG 10) of sustainability development goals (SDGs). Additionally, the trend topics are also driven by sustainability goals. In recent years, scholarly work appears to have been concentrated around "collective action" and "artificial intelligence" opportunities.

The integrative review allows us to conclude that the current state of research is able to form the framework foundations for the innovative integration of HRM in labor-saving technologies in agriculture. Moreover, we created a conceptual framework using the 7-S McKinsey model to visualize the complex linkages that require the successful integration of strategic HR (renewable strategy) and restructuring of the organization with workforce skill development and productivity. The productivity and efficiency in agricultural operations were partially proved to be positively linked with the integration of HRM functions. In addition, the appropriate implementation in agricultural firms was influenced by the role of technology, training and development, change management, labor allocation, sustainability allocation, regulatory compliance, and knowledge management in agricultural firms' HRM functions. This review contributes to comprehending the integrative role that HRM has in the performance of the business, which incorporates labor-saving technologies in their daily operations, and it benefits agricultural researchers, managers, and policymakers by providing a comprehensive and integrative perspective of the topic. *Future directions*: Future work must include the setting up of a recommendation system, which can offer guides for farmers and decision-makers in comparing and selecting the most appropriate labor-saving technologies and HRM practices for the subsector they operate their businesses. This results in more efficient, productive, competitive sectors and a sustainable agricultural industry. The ongoing research into HR readiness for new technologies and opportunities, which are outlined in [80], can provide valuable insights and practical solutions for the agribusiness sector. We recommend the inclusion of an HR renewal strategy into the business model to manage the changes caused by the implementation of labor-saving technologies in agricultural business activities. Furthermore, few studies examine the regional effect (geographical and regional factors) on labor-cost adoption technologies. *Limitations:* Our paper only analyzed data obtained from the Scopus database and was based solely on literature advances. In addition, the constraint may stem from the methodology limitations.

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Abbreviations

HR	Human Resources
HRM	Human Resource Management
UN	United Nations
ICTs	Information and Communication Technology
IT	Information Technology
SFTs	Sustainable Farming Technologies
SDGs	Sustainable Development Goals
IoTs	Internet of Things
ML	Machine Learning

Appendix A

Table A1 contains further details on the primary search query used in this study. In addition, it summarizes the inclusion and exclusion criteria based on language, topic area, document type, and years that were considered for this study.

Table A1. The search process information. Source: Authors' work.

Main Query	**TITLE-ABS-KEY ("Technology Adoption" AND "Human Resources" OR "Human Resource Management" OR "hr" OR "hrm" OR "Agricultural Labor" OR "Agriculture Workforce" OR "Agricultural Employment")**	
Inclusion	Language	English Language
	Subject area	Agricultural and Biological Sciences; Social Sciences; Economics and Econometrics; Business, Management and Accounting; Decision Sciences.
	Document type	Articles, reviews, conference papers
	Period	2013–2023 (PUBYEAR > 2012 AND PUBYEAR < 2024)
Exclusion	Document type	Book chapter (3), short survey (4)
	Language	Chinese (3), Spanish (2), Japanese (1)
	Subject area	Environmental Science; Computer Science; Engineering; Psychology; Medicine; Energy; Mathematics; Earth and Planetary Sciences; Art and Humanities; Biochemistry; Genetics and Molecular biology; Physics and Astronomy; Material Sciences; Health Professions; Chemical Engineering.

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