Bibliometric Insights: Integrating Human Resources and Technology for Sustainable Pathways

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Abstract

Amid unprecedented global challenges, integrating sustainability, HR strategies, and technology has become crucial for academia and industry. This paper explores research at this intersection, revealing synergies shaping sustainable development through a bibliometric framework. Using the Scopus database, 243 documents were analyzed with VOSviewer and R-studio. The findings indicate an increasing trend in integrating technological innovations with HR strategies for sustainable development. The United States leads with 34 manuscripts, while the National Natural Science Foundation of China sponsors the most studies (4). Thematic mapping, co-occurrence analysis, and word clouds provide insights into the interconnectedness of sustainability, HR strategies, and technology. These findings guide stakeholders in shaping policies, organizational strategies, and educational initiatives to advance sustainable development goals (SDGs). The study highlights the need for collaboration between academia, industry, and policymakers to leverage technology and HR strategies, fostering innovation, improving decision-making, and promoting a culture of sustainability for a resilient, equitable global society.

Keywords: Bibliometric, Human Resource, Strategies, Sustainability, Technology.

Introduction

The integration of sustainability and sustainable development goals (SDGs) into organizational strategies has gained significant attention in recent years (Lozano & Barreiro-Gen, 2023).The pursuit of sustainability has become a critical objective across various sectors (Hariram et al., 2023), driven by the urgent need to address environmental, social, and economic challenges. (Wang, 2024) states that the United Nations' SDGs provide a comprehensive framework for achieving global sustainability by 2030. These goals encompass a wide range of targets, including promoting decent work (Conigliaro, 2019), fostering innovation (Awan, 2021), and ensuring responsible consumption and production patterns (Kalansooriya, 2023).In the corporate sector, Human Resource (HR) strategies play a pivotal role in embedding sustainability into organizational culture and practices

(Aggarwal & Agarwala, 2023). Effective HR strategies are essential for fostering a workforce that is not only skilled and motivated but also aligned with the principles of sustainability. This alignment is crucial for achieving long-term organizational success and contributing to broader societal goals (Stahl et al., 2020). It has been emphasized by (Mondejar et al., 2021) that technological advancements amplify the potential for sustainable development. Technologies such as artificial intelligence (AI), big data, and the Internet of Things (Iota) are transforming how organizations operate, offering innovative solutions for enhancing productivity, efficiency, and sustainability. The integration of technology with HR strategies can lead to significant improvements in workforce management (Zehir et al., 2020), employee engagement (Heslina & Syahruni,2021), and the implementation of sustainable practices(Mukhuty et al., 2022).In an era defined by complex global challenges, the pursuit of sustainable development has become a paramount objective for societies worldwide(Tavares et al., 2022). Amidst this backdrop, the integration of HR strategies and technological innovations emerges as a critical area of focus for both academia and industry. (Hernandez, 2021) highlights that thisconvergence holds the promise of fostering more resilient, efficient, and equitable pathways toward SDGs. By leveraging technological advancements, organizations can enhance their human resource management practices, driving innovation, efficiency, and sustainability. Concurrently, strategic HR initiatives can facilitate the adoption and optimization of technological solutions (Fernandez & Gallardo-Gallardo, 2021), ensuring that technological progress is aligned with organizational goals and sustainable development objectives(Popkova et al., 2022).

The integration of HR strategies with sustainability initiatives is increasingly recognized as a vital component for achieving SDGs within organizations(Mukhuty et al., 2022). HR plays a crucial role in embedding sustainability into the fabric of an organization, from fostering a culture of sustainability to implementing practices that promote long-term environmental, social, and economic benefits(Viterouli et al., 2023). Effective HR strategies involve recruiting and retaining employees(Alrashedi, 2024) who are not only skilled and motivated but also aligned with the principles of sustainability. This alignment is essential for driving innovation, enhancing productivity and ensuring responsible consumption(Tepliuk et al., 2023) and production patterns. Moreover, HR departments are pivotal in providing continuous training and development opportunities(Mogea, 2023) that equip employees with the necessary skills to support sustainable practices.

Despite the growing recognition of the importance of sustainability, the intersection of sustainability, SDGs, HR strategies, and technology remains a relatively underexplored area in academic research. This paper aims to fill this gap by conducting a bibliometric analysis to map the scholarly landscape of research in this multidisciplinary domain. By examining publication trends, identifying influential works, and uncovering thematic clusters, this study provides a comprehensive overview of how these fields intersect and contribute to the achievement of sustainability goals.Also, by integrating sustainability into HR policies and practices, organizations can create a workforce that is engaged, empowered and committed to contributing to broader societal goals. This holistic approach to human resource management not only supports the achievement of SDGs but also fosters a resilient and adaptive organizational culture that can thrive in the face of global challenges.The findings will provide valuable insights for researchers, practitioners, and policymakers seeking to understand the dynamics of this intersection and leverage its potential for achieving sustainability goals. The entire manuscripts has been divided into seven sections including the second one as the methodology, followed by analysis of data and interpretation, implications, limitations and the last one as conclusion of the study.

Literature Review

Sustainability and Sustainable Development Goals (SDGs)

Sustainability and the SDGs have garnered significant academic and policy attention since their introduction by the (United Nations, 2015). The SDGs encompass 17 goals that address global challenges such as poverty, inequality, climate change, environmental degradation, and peace and justice(Dube et al., 2021). Research by (Mio et al., 2020)

indicates that businesses play a crucial role in achieving these goals by integrating sustainable practices into their operations and strategies .

Human Resource (HR) Strategies for Sustainability

(Stahl et al., 2020) claim thathuman resource management(HRM) has evolved to include sustainability as a core component of its strategies. Green HRM practices, which integrate environmental management into HR policies, have been shown to enhance organizational sustainability(Amjad et al., 2021). These practices include eco-friendly recruiting(Naz et al., 2024)and performance management(Al Aina & Atan, 2020), as well as promoting a sustainability-oriented organizational culture(Rubio-Andrés & Abril, 2024). Additionally, (Podgorodnichenko et al., 2022) highlight that HR strategies focused on employee well-being, diversity, and inclusion contribute to the social dimension of sustainability.

The Role of Technology in HR and Sustainability

Technological advancements have revolutionized HR practices, making them more efficient and effective. Technologies such as artificial intelligence (AI), and machine learning as brought to light by (Garg et al., 2022) enable more precise talent managementand enhanced employee engagement through personalized learning and development programs .

In the context of sustainability, technology plays a pivotal role in monitoring and reducing environmental impact. For instance, (Rane, 2023) emphasize that AI and Internet of Things(IoT) can optimize energy use in buildings, manage waste more efficiently, and track supply chain sustainability. The integration of these technologies into HR strategies(Ejibe et al., 2024) not only improves operational efficiency but also aligns organizational practices with sustainability goals .

Intersection of Sustainability, HR Strategies, and Technology

The intersection of sustainability, HR strategies, and technology represents a promising area for achieving comprehensive sustainable development. Studies have shown that organizations that integrate technological innovations with sustainable HR practices (Podgorodnichenko et al., 2022) are better positioned to meet their sustainability targets. For example, digital learning platforms can provide employees with continuous education on sustainability practices(Nuraini, 2024), while (Belhadi et al., 2023) highlighted that data analytics can track and report on sustainability performance metrics .

However, the literature also highlights several challenges in this integration. These include the need for substantial investments in technology(Haessler et al., 2023), the complexity of aligning diverse organizational goals with sustainability(Pache et al., 2024), and potential resistance to change within organizations. Addressing these challenges requires a strategic approach that involves leadership commitment, stakeholder engagement, and continuous evaluation of sustainability initiatives.

Bibliometric Analysis

(Donthu et al., 2021) highlights that bibliometric analysis is a quantitative method used to evaluate the impact and development of a particular field of research. A systematic literature review has been conducted by (Chams et al., 2019) highlighting aspects of sustainable human resource management with SDGs. (Naz et al., 2024) have also highlighted the same in relation to green employability. Moreover, studies(Faisal, 2023) have focused on SDGs and HR practices through bibliometric findings, but the bibliometric study of the intersection of tech with SDGs and HRM strategies still remains an unexplored area.

Research Methodology

To achieve the objective of the growing importance of integrating technological innovations with HR strategies to drive sustainable development through bibliometric study, the following research questions have been proposed:

RQ1- What is the publication trend per annum of the works published about the intersection of sustainability, HR strategies and technology?

RQ2-Which are the top ten leading countries that have added maximum publications about the intersection of sustainability, HR strategies and technology?

RQ3-Which document type has the highest publications about the intersection of sustainability, HR strategies and technology?

RQ4-Who are the funding sponsors of the manuscripts about the intersection of sustainability, HR strategies and technology?

RQ5-What is the thematic mapping of keywords in manuscripts about the intersection of sustainability, HR strategies and technology?

RQ6-What does the co-occurrence analysis demonstrate about the intersection of sustainability, HR strategies and technology?

RQ7-What does the word cloud reveal for manuscripts about the intersection of sustainability, HR strategies and technology?

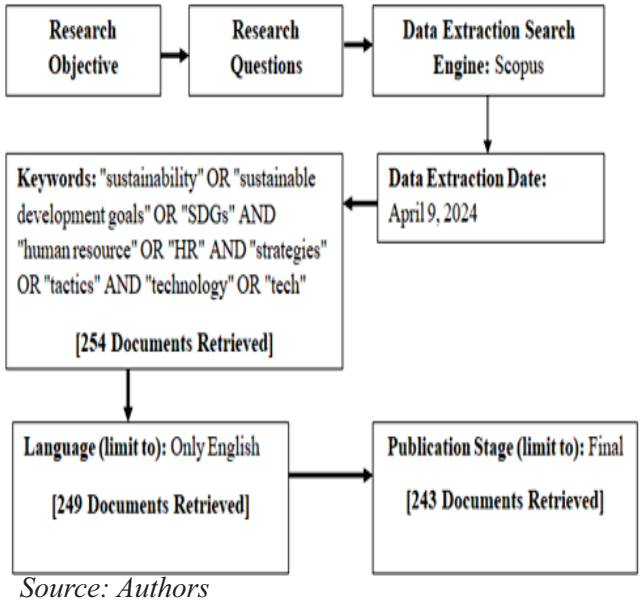
The current work employs the usage of Scopus database to extract manuscripts in relation to the string: "sustainability" OR "sustainable development goals" OR "SDGs" AND "human resource" OR "HR" AND "strategies" OR "tactics" AND "technology" OR "tech". The process took place on April 9, 2024. It has been observed that a total of 243 documents were sorted following the extraction model as shown in table 1 and figure 1. VOSViewer and bibliometrix package of R-studio software are used for visualization of the data analysis. Also, Microsoft excel has been used to create charts for data representation.

Table 1: Sorting Criteria

Criteria	Rejected Manuscripts	Accepted Manuscripts
Keywords: "sustainability" OR "sustainable development goals" OR "SDGs" AND "human resource" OR "HR" AND "strategies" OR "tactics" AND "technology" OR "tech"	-	254
Language(limit to): Only English	5	249
Publication Stage(limit to): Final	6	243

Source: Authors

Figure 1: Documents' Extraction Framework



Source: Authors

Data Analysis and Interpretation

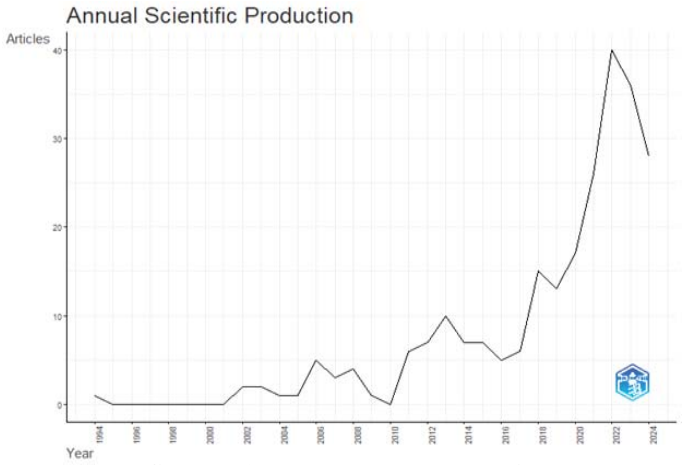
Publication trend per annum of the works published about the intersection of sustainability, HR strategies and technology

Figure 2 represents the yearly publication trend of the manuscripts published about the intersection of sustainability, HR strategies and technology. It is observed that there is a single paper published in the year 1994. Also, since 1995 to 2001 there have been no publications in this field. From 2002 to 2019, there have been ups and downs in the publications counts. However, from the year 2020(17), there has been an increasing trend to a count of 26 in the year 2021, 40 in the year 2022, decreasing to 36 in the year 2023 and 28 in the year 2024. It is observant that it is only a quarter of the year 2024, and there have been already publications about the intersection of sustainability, HR strategies and technology.

It is interpreted that the ups and downs in the publication counts from 2002 to 2019 may reflect the developing nature

of this interdisciplinary field. Fluctuations could be influenced by factors such as changes in research funding, evolving corporate priorities, and the pace of technological innovation. Also, global events, such as the COVID-19 pandemic starting in 2020, may have accelerated interest and research in sustainability and technology, as organizations reevaluated their strategies for resilience and sustainability in response to global disruptions. The substantial increase in publications from 2020 onwards coincides with heightened global awareness and action towards sustainability, possibly driven by international agreements, corporate sustainability goals, and technological advancements.The continuing upward trend into 2024 suggests sustained and possibly growing interest in this field. Given that only a quarter of 2024 has passed and 28 publications have already been recorded, the year may end with a significant number of contributions, possibly surpassing previous years.

Figure 2: Annual Scientific Production



Source: Authors through R-studio

Top ten leading countries that have added maximum publications about the intersection of sustainability, HR strategies and technology

It has been demonstrated in table 2 that United States(34) has contributed the maximum till date in publishing documents about the intersection of sustainability, HR strategies and technology. India is competitive herein, giving a count of 32 manuscripts in the related field, followed by Indonesia(20), United Kingdom(16) and China(14). It has been further revealed that Australia(12) is also making efforts in contributing to manuscripts for sustainability and technology with HR strategies, followed by Canada and Germany both counting to 10 manuscripts each. Brazil has given 7 documents and 6 documents have been registered in the account of Italy.

The leadership of the United States and significant contributions from countries like India and the United Kingdom indicate a prioritization of sustainability and technological integration in HR strategies within these nations. This reflects broader national strategies and funding allocations aimed at addressing global sustainability challenges. The diverse contributions from countries across different continents highlight the potential for international collaboration. Sharing knowledge and best practices can enhance the global impact of research in this field. The distribution of contributioncountry-wise also suggests opportunities to strengthen global research networks. Collaborative projects and joint initiatives can leverage the strengths of leading countries and emerging research hubs, promoting knowledge exchange and innovation.

Table 2: Country-wise Representation

S.No.	Country	Number of Documents
1.	United States	34
2.	India	32
3.	Indonesia	20
4.	United Kingdom	16
5.	China	14
6.	Australia	12
7.	Canada	10
8.	Germany	10
9.	Brazil	7
10.	Italy	6

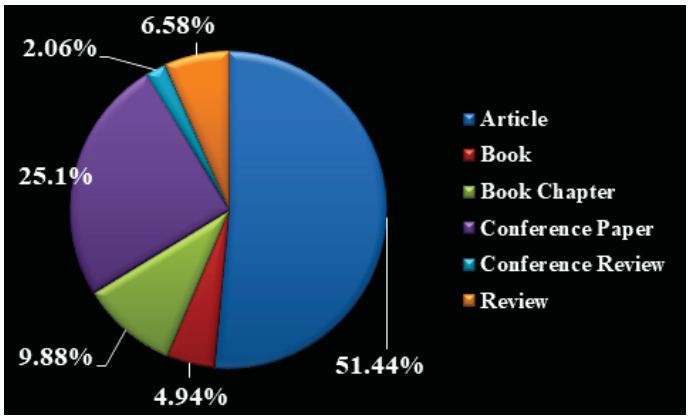
Source: Authors

Document type that has the highest publications about the intersection of sustainability, HR strategies and technology

Figure 3 represents the type of document that hasbeen published about the intersection of sustainability, HR strategies and technology. Articles contributes maximum(51.44%) to the publications, followed by conference paper(25.1%). Moreover, book chapters have also gained strength contributing to 9.88% of the manuscripts published in relation to sustainability, HR strategies and technology. There are reviews, books and conference reviews that are contributing manuscripts in the related topic making 6.58%, 4.94% and 2.06% respectively.

Articles constitute the majority of the publications, indicating that the primary mode of disseminating research findings is through peer-reviewed journal articles. This suggests a strong emphasis on rigorous, detailed research that undergoes peer evaluation. The substantial proportion of conference papers highlights the field's dynamic nature, where new ideas and preliminary research findings are frequently shared and discussed. Conferences facilitate real-time feedback and collaboration opportunities, driving the field forward. The notable contribution of book chapters indicates a growing interest in comprehensive, thematic explorations of the intersection of sustainability, HR strategies, and technology. Reviews account for a smaller yet important portion of the publications. Review articles play a crucial role in summarizing existing research, identifying gaps, and proposing future research directions. Thus, a balanced approach to different publication types can enhance the impact of research.

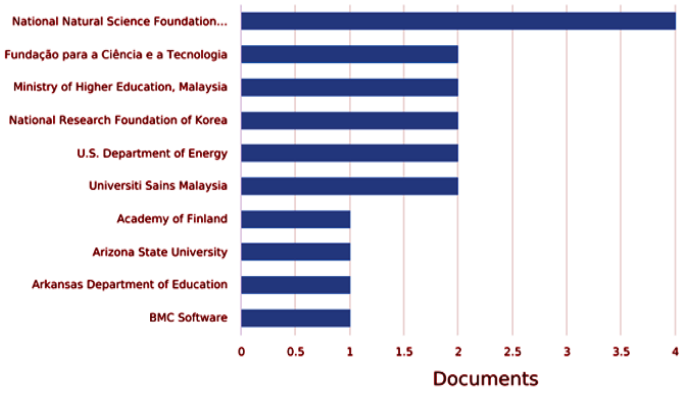
Figure 3: Type of Documents Published



Funding sponsors of the manuscripts about the intersection of sustainability, HR strategies and technology

It is visible in figure 4 of the various funding sponsors of the documents published about the intersection of sustainability, HR strategies and technology. National Natural Science Foundation of China has sponsored 4 manuscripts till date in the context of intersection of sustainability, HR strategies and technology, followed by Fundacao para a Ciencia e a Tecnologia(Portugal), Ministry of Higher Education(Malaysia), National Research Foundation of Korea(South Korea), U.S. Department of Energy(United States), and Universiti Sains (Malaysia) each funding two documents till date. Additionally, it has been observed thatAcademy of Finland, Arizona State University, Arkansas Department of Education and BMC Software.

Figure 4: Sponsors for the Manuscripts in Consideration



Source: Authors through Scopus database

Thematic mapping of keywords in manuscripts about the intersection of sustainability,

HR strategies and technology

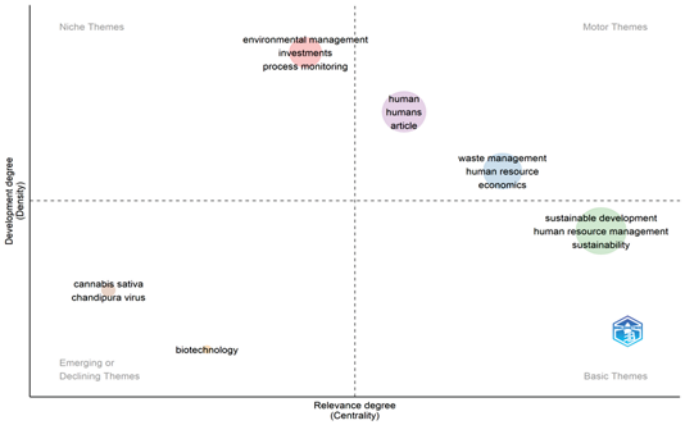
Figure 5 represents the thematic mapping of keywords for the manuscripts published about the intersection of sustainability, HR strategies and technology. The thematic map consists of four quadrants labeled as Q1:motor themes, Q2:niche themes, Q3:emerging or declining themes and Q4:basic themes. This map is used to visualize different themes in the field of intersection of sustainability, HR strategies and technologyon their relevance and

development degree. The x-axis represents the relevance degree or centrality that measures how relevant or central a theme is to the field. Higher centrality indicates that the theme is more integrated into the core topics of the field. The y-axis represents the development degree or density that measures how developed or mature a theme is. Higher density indicates that the theme has a well-formed body of research and is well understood. The motor theme shows high relevance and high development, indicating well-developed and crucial themes in the field such as "waste management", "human resources" and "economics." The niche theme is indicative of high development and low relevance. These include cluster of those keywords which are well developed but not central to the field. Moving on to Q3, in the emerging or declining themes, low relevance and low development keywords are presented, highlighting either emerging areas of research or themes that are declining in importance. The Q4 of basic themes emphasizes on high relevance but low development of the keywords that are central to the field but not yet well developed.

Also,each cluster represents a theme, and its size may represent the volume of research or publications related to that theme. Thus, motor themes like "sustainable development" and "human resource management" are both highly relevant and well developed, indicating they are integral and mature themes within the field. Niche themes like "environmental management" are highly developed but not as central, suggesting they are specialized areas of research. Basic themes like "waste management" have high relevance but require further development to become mature areas of research and emerging or declining themes like "cannabis sativa" and "biotechnology" is in the early stages of development or possibly losing relevance in the field.

The thematic map highlights the importance of sustainability and HR strategies as central, well-developed themes. Technology, while currently a niche or emerging theme, holds significant potential to support and enhance these areas. By integrating advanced technologies with sustainability initiatives and HR strategies, organizations can create a synergistic effect that promotes sustainable development and efficient human resource management. This intersection is pivotal for future research and practical applications, aiming for a sustainable and technologically advanced future. Sustainability and HR strategies are both identified as Motor Themes, meaning they are integral to the field and well-researched. The intersection of these two themes is crucial for developing sustainable business practices. Although technology-related themes like biotechnology and process monitoring are not as central, they play a critical role in enhancing both sustainability and HR strategies.

Figure 5: Thematic Mapping of Keywords



Source: Authors through R studio

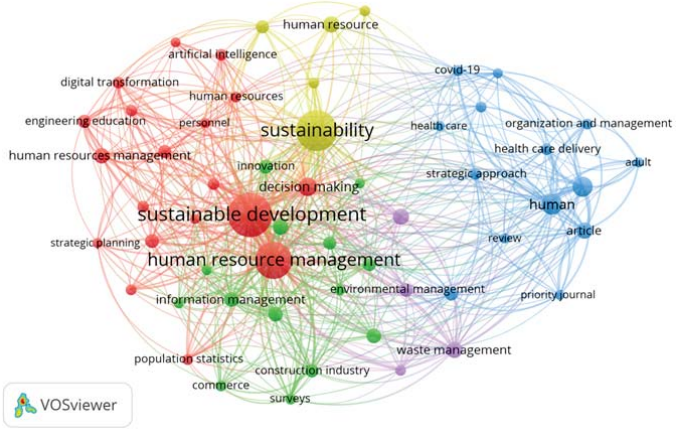
Co-occurrence analysis demonstrationabout the intersection of sustainability, HR strategies and technology

The co-occurrence analysis of all keywords in shown in figure 6, representing a total of five clusters, when 56 keywords met the limit of minimum occurrence to be 5 each.This analysis is instrumental in understanding how various themes are interconnected and which areas are most prominent (Kristanto&Padmi, 2020).Cluster 1 is demonstrated in red color, indicating a total of 19 items. This cluster is the largest one and has keywords such as "human resources", "sustainable development" and "long-term sustainability". Moreover, the second largest cluster is green in color representing a total of 14 keywords such as "developing countries", "environmental management", "information management" and "commerce". The third

cluster is the blue one in 14 items, consisting of keywords such as “human”, “strategic approach”, “organizations” and “management.” Cluster 4 is yellow in color showing five items such as “industry 4.0” and “industrial research.” Atlast, the fifth cluster shown in purple color has four keywords in all: “environmental impact”, “environment management”, “environmental technology” and “waste management”.

The clustering of keywords into distinct groups reveals the diverse yet interconnected nature of research themes within the field of the intersection of sustainability, HR strategies and technology. Keywords that frequently co-occur are grouped together, reflecting their interconnectedness in the research literature. Some clusters are more specialized, indicating focused research areas like Industry 4.0 or environmental technologies. It has been interpreted that themes that are both highly relevant and well-developed (e.g., sustainability and HR) form larger clusters, while emerging or niche themes form smaller, more specialized clusters.The largest cluster (Cluster 1, Red) suggests a strong interconnection between HR practices and sustainability. This indicates that research frequently explores how human resource strategies can contribute to sustainable development goals, highlighting the critical role of HR in fostering long-term sustainability.The analysis highlights key thematic areas, emerging research trends, and the integration of various topics within the broader field. It provides valuable insights into the central themes driving research and the specific areas where more focused studies are occurring.

Figure 6: Co-occurrence Analysis of Keywords



Source: Authors through VOSViewer

Word cloud revelation for manuscripts about the intersection of sustainability, HR strategies and technology

Word Cloud has been represented in figure 7, which is a visual representation of the frequency of keywords in the 243 manuscripts published about the intersection of sustainability, HR strategies and technology. In this word cloud, the size of each word indicates its frequency or importance within the context (Eichstaedt et al., 2021). The prominent keywords are “sustainable development” and “human resource management”. “Sustainable development” is the largest, indicating that it is the most frequently occurring keyword. This suggests that sustainable development is a central theme in the data extracted. Another major keyword, “human resource management”, highlighting the significant role of HR management in the context of sustainable development. "Sustainability"is also prominently featured, indicating its close relation to sustainable development and HR management and "Waste Management's visibility suggests it is a critical component of discussions around sustainability. Also,"Environmental Technology" is present that highlights the importance of technological solutions in addressing environmental challenges.

The word cloud reinforces the idea that sustainable development and human resource management are pivotal areas of study, often intersecting with technological innovations. The frequent occurrence of related terms suggests a multidisciplinary approach, integrating environmental management, strategic decision-making, and technological solutions to address sustainability challenges. This visualization complements the co-occurrence analysis by highlighting the most frequent and significant keywords, providing a quick overview of the research landscape. It underscores the importance of combining sustainability with effective HR strategies and technological advancements to achieve comprehensive and long-term sustainable development goals.

Figure 7: Word Cloud

Source: Authors through R studio

Implications

The implications of the research questions provide a detailed understanding of the current state of research at the intersection of sustainability, HR strategies, and technology. It offers insights that can inform policy decisions and best practices for integrating technology and HR strategies to drive sustainable development. Moreover, this bibliometric analysis highlight trends, gaps, and opportunities that can shape future research directions and funding priorities. The study further identifies key players and regions, promoting collaboration and knowledge sharing across borders and disciplines.

Limitations and Suggestions

The study is limited to take into consideration only one database, i.e., the scopus database. However, it is recommended that further research can be employed by considering a combination of databases such as web of science and EBESCO. Also, more keywords can be added to the string chosen in the related field. The exclusion of network analysis such as co-authorship or bibliographic coupling and co-citation analysis can be further studied in the upcoming research manuscripts. Empirical studies are suggested for future research in the field of technology and HR strategies contributing to SDGs.The study confines itself only to a specific number of research questions being framed, thus narrowing down the scope of research in this interconnectedness.

Conclusion

This paper has explored the critical intersection of sustainability, HR strategies, and technology through a comprehensive bibliometric analysis. By examining publication trends, influential works, and thematic clusters, the study aims to provide a comprehensive overview of how these domains interact and contribute to the achievement of sustainability goals. The observed trends in publication counts reflect the growing importance and evolving nature of research at the intersection of sustainability, HR strategies, and technology. The United States has emerged as the leading contributor, highlighting the significant role of the U.S. in advancing research at the intersection of sustainability, HR strategies, and technology. Also, the National Natural Science Foundation of China has provided the highest count of sponsorships (4) in this area, indicating the foundation's commitment to supporting research that bridges sustainability, HR strategies, and technology. Moreover, thematic mapping, co-occurrence analysis, and word cloud visualization reveal the interconnectedness and key themes within the context and highlight the central themes, emerging research areas, and the overall structure of the research landscape. Furthermore, the study also identifies several areas for future research, including the exploration of emerging technologies, the development of new HR strategies aligned with sustainability goals, and the examination of regional differences in research contributions. Further research in these areas can provide deeper insights and support the continued advancement of this critical field. The insights derived from this study offer actionable guidance for stakeholders, including policymakers, industry leaders, and educators. By understanding the key themes and trends, stakeholders can thus, shape policies, organizational strategies, and educational initiatives to advance SDGs.

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