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INTERPLAYS BETWEEN ARTIFICIAL INTELLIGENCE AND SUSTAINABILITY IN BUSINESS / MANAGEMENT. A BIBLIOMETRIC ANALYSIS

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Abstract:

The paper aims to identify the main research (threads and) trends and evaluate the relationships between (and the impact of) the publications/articles investigating the interplays between artificial intelligence (AI) and sustainability against a business or management related context. To reach this objective, 863 articles from Web of Science Core Collection were analyzed, using VOSviewer as a bibliometric tool. Performance analysis was employed to mainly explore the interest and popularity of the topic, assess the main interest areas and fields of both the sources and the publications, determine the most relevant SDGs for the topic, and identify the most popular journals hosting articles in the analyzed field. Science mapping was carried out to identify the most influential articles in the field, understand the antecedent topics/ideas (in the fields of AI and sustainability, respectively) contributing to the emergence of a new interest area at the intersection between AI and sustainability, appraise the current developments in the analyzed interest area, and discover new trends / areas for future research.

Key words: *artificial intelligence; bibliometric analysis; business/management; sustainability; twin transition.*

1. Introduction

Sustainability and digitalization are two of the biggest issues business leaders and policymakers are facing nowadays. Basically, sustainability is about meeting “the needs of the present without compromising the ability of future generations to meet their own needs” (UN World Commission on Environment and Development, 1987); digitalization, on the other hand, refers to the “integration of digital technologies into everyday life by the digitization of everything that can be digitized” (Khosrow-Pour, D.B.A., 2018). The recent increase in the output of scholarly literature reflects the concerns about sustainability and digitization in a business or management-related setting. Thus, a quick search in Web of Science Core Collection (by topics, only Articles in English considered) for [sustainability AND (business OR management)] generated 14290 documents published in 2022 (compared to 7230 in 2018); the similar search for [digitalization AND (business OR management)] returned 1698 documents published in 2022 (compared to 216 in 2018).

The challenges of **sustainability** and the consequences of neglecting/minimizing them (e.g., climate change, food insecurity, biodiversity loss, resource depletion, waste generation, divides and inequalities, social and ethical issues) have been intensively studied by academia (D'Amato et al., 2017; Ellili, 2023; Jia et al., 2019; Sharifi, 2021), while programmatically addressed by international bodies – especially through the United Nations's 2030 Agenda for Sustainable Development (UN, 2015) and the European Commission's Green Deal Strategy (European Commission, 2019), both urging for the participation and collaboration of all the global actors. Consequently, the shift to sustainability / the green transition has largely been (at least declaratively) accepted as path for future growth by organizations of all types (from businesses to public institutions) and sizes.

At its turn, **digitalization** has increasingly penetrated all the areas and levels of human activity, becoming "a technological trend that is reshaping all sectors of our industry and society today" (Lang, 2021). Hence, academics have examined the challenges and impacts of (both embracing and rejecting) digitalization (and the plethora of digital technologies that enables it) from a variety of perspectives – i.e. industry 4.0 (Alcácer & Cruz-Machado, 2019), supply chain (Queiroz & Fosso Wamba, 2019), business model innovation (Rachinger et al., 2019), servitization (Cenamor et al., 2017), retailing (Hagberg et al., 2016), social services (Ranerup & Henriksen, 2019), healthcare (Sanchez-Pinto et al., 2018), smart city (Serrano, 2018) or smart farming/agriculture (Ingram et al., 2022) – while the European Commission, aiming at A Europe fit for the digital age (European Commission, 2020), has made the digital transition / transformation another of its priorities.

In conjunction with this, a new approach has recently emerged – i.e., to combine the sustainability and digitalization agendas into a **twin transition** by tackling the two sets of goals/objectives in a coordinated and integrated manner. Thus, the twin transition pertains to the simultaneous (and ideally reinforcing one another, despite their incongruencies) transformation towards sustainability and digitalization of businesses/organizations and the society at large – specifically by capitalizing the capacity of digital technologies to enable and accelerate the transition towards the sustainability goals – in search of a green and digital future (European Commission. Joint Research Centre, 2022). Researchers have started to explore topics related to the twin transition, either by directly referring to the concept (Almansour, 2022; Fouquet & Hippe, 2022; Ogrean & Herciu, 2021) or by investigating some of its valences / defining interferences (Kristoffersen et al., 2020; Pappas et al., 2018; Parida et al., 2019).

Of the multitude of digital technologies enabling digitalization while impacting sustainability (both positively and negatively), **artificial intelligence** (AI) has recently gained momentum. Defined as "the ability of ta machine to display human-like capabilities such as reasoning, learning, planning and creativity" (European Parliament, 2023), AI became central in the process of digital transformation of society. It is revealed to have huge potential contributions (towards sustainability) in various areas (e.g., business/management, energy, healthcare, agriculture, mobility, security), while (similarly significant) associated risks (e.g., energy consumption, carbon emissions, e-waste, data privacy, ethical dilemmas, labor displacements) (Schmidpeter & Altenburger, 2023; Van Wynsberghe, 2021; J. Zhao & Gómez Fariñas, 2023). The **objective** of this study is to identify the main research (threads

and) trends and evaluate the relationships between (and the impact of) the publications/articles investigating the interplays between artificial intelligence (AI) and sustainability against a business or management related context. To reach this objective, both performance analysis and science mapping (Donthu et al., 2021) were performed – using Web of Science scientific database for data collection and VOSviewer for bibliometric analysis.

The remainder of the paper is organized as follows: the **Methodology** section provides details on the data collection process and the methods employed for the bibliometric analysis; then, the **Data Analysis and Results** section is divided into Performance analysis and Science mapping and visualization; the **Conclusions** section reviews the results against the stated objective and suggests areas for future developments in the investigated research field.

2. Methodology

Web of Science (WoS) database – "the world's leading universal citation database that is publisher independent" (Kasaraneni & Rosaline, 2022), largely used by academia for bibliometric analysis in areas related to AI and/or sustainability (Gandia et al., 2019), (Z. Wang & Liao, 2020), (Liu et al., 2021), (Yang et al., 2022) – was chosen to collect the data for analysis.

The selection of documents for analysis (Table 1) started with an initial query in WoS Core Collection by Topic (title, abstract, author keywords, and keywords plus) – [*ai OR "artificial intelligence"] AND sustainab* AND [business OR management]* – and Publication date (*2018 to 2022*). The query considered the two main topics/challenges (*ai* AND *sustainability*) and the (*business* OR *management* – related) context of their convergences, as well as the timespan able to capture the most recent trends in the field (last five full years). The results (1375 records) were refined using the Document Type (Article) and Language (English) as including criteria, while excluding the following Document Types: Early Access, Book Chapters, Proceeding Paper, Retracted Publication, and Data Paper. The resulted set consisted of 863 documents/articles, all retained for analysis; data – full record and cited references – were exported in Tab-delimited file format, to ensure their compatibility with VOSviewer (Van Eck & Waltman, 2023).

Table 1. Selection of Documents for Analysis

Selection Process	Records
Initial query in WoS *ai or "artificial intelligence" (Topic) and sustainab* (Topic) and business or management (Topic)* *Timespan: 2018-01-01 to 2022-12-31 (Publication Date)*	
Refined by:	1375
✓ Document Types: Article	
✓ Languages: English	939
✓ NOT Document Types: Early Access or Book Chapters or Proceeding Paper or Retracted Publication or Data Paper	918 55
Documents for analysis	863

Source: Authors, based on WoS data

The software tool utilized for the bibliometric analysis was VOSviewer version 1.6.19 (vosviewer.com), "a freely available computer program (…) developed for constructing and viewing bibliometric maps" (Van Eck & Waltman, 2010). Being "technically robust and relatively simple to use" (Kirby, 2023), VOSviewer is being increasingly used by academia to map the scientific field in areas related to the current topic (Guo et al., 2019), (Pizzi et al., 2020), (J. Wang et al., 2021), (Grabowska et al., 2022).

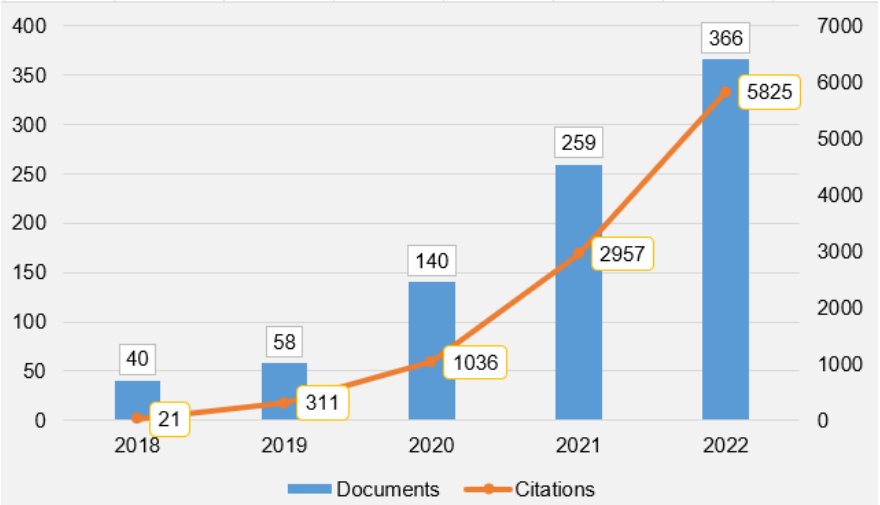
Based on WoS data (and its Analyze Results and Citation Report tools) and VOSviewer mapping (based on bibliographical data), several analyses have been employed. Thus, the performance analysis mainly targeted: overall publication and/or citation metrics – to explore the interest and popularity of the topic; WoS Categories and Research Areas – to assess the main interest areas and fields of both the sources and the publications; Sustainable Development Goals (SDGs) – to determine the most relevant SDGs for the topic; and the top five source titles and their citations – to identify the most popular journals hosting articles in the analyzed field. On the other hand, the following techniques have been used for science mapping: citation analysis – to identify the most influential articles in the field; co-citation analysis – to understand the antecedent topics/ideas (in the fields of AI and sustainability, respectively) contributing to the emergence of a new interest area at the intersection between AI and sustainability; bibliographic coupling – to appraise the current developments in the analyzed interest area; co-occurrence of authors keywords – to back/validate the findings from the bibliographic coupling analysis and discover new trends / areas for future research.

3. Data Analysis and Results

3.1. Performance analysis

WoS returned a total of 863 documents/articles that matched the search parameters; together, they accumulated 10150 citations over the examined period (Figure 1). The steep increase in documents (from 40 in 2018 to 366 in 2022) and citations (from 21 in 2018 to 5825 in 2022) indicates the growing interest of academia in examining the relationships between two major challenges of nowadays - AI and sustainability - in a business/management context.

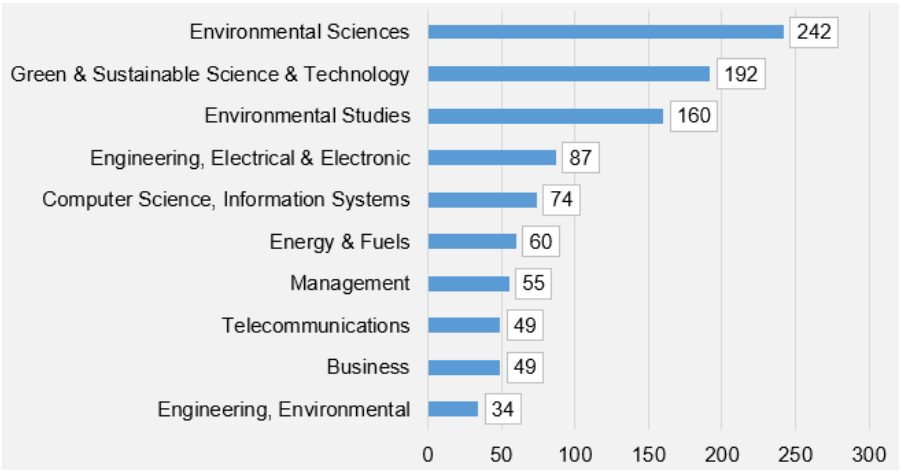
Figure 1. Documents and Citations



Source: Authors, based on WoS data

The journals publishing the 863 documents fall under 122 WoS subject Categories (N.B. each journal is assigned to at least one Category). More than two thirds of the documents (68.83%) are hosted by journals allocated to three WoS Categories - Environmental Sciences, Green & Sustainable Science & Technology, and Environmental Studies; around half of the articles (47.28%) are published in journals falling under one of the following WoS Categories, helping to complete the Top 10 Wos Categories (Figure 2): Engineering Electrical & Electronic, Computer Science Information Systems, Energy & Fuels, Management, Telecommunications, Business, and Engineering Environmental.

Figure 2. Top 10 WoS Categories (records, of 863)

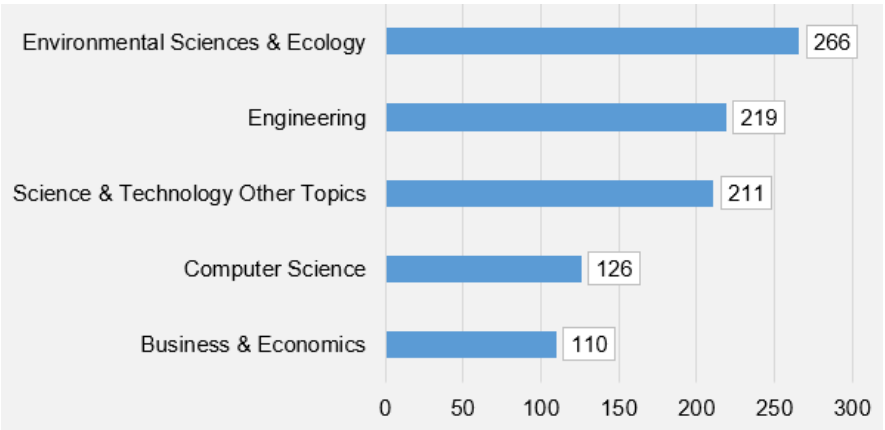


Source: Authors, based on WoS data

The articles tackle 74 Research Areas (N.B. multiple Research Areas could be associated to each record), covering all the five WoS's Research Areas broad categories. However, there are five Research Areas, each collecting more than 100 articles, to which

eventually each article is assigned (Figure 3): Environmental Sciences & Ecology (30.82% of all records) - falling under the Life Sciences & Biomedicine Research Area broad category); Engineering (25.38% of all records), Science & Technology Other Topics (24.45% of all records), Computer Science (14.60% of all records) - falling under the Technology Research Area broad category; Business & Economics (12.75% of all records) - falling under the Social Sciences Research Area broad category).

Figure 3. Top 5 Research Areas (records, of 863)

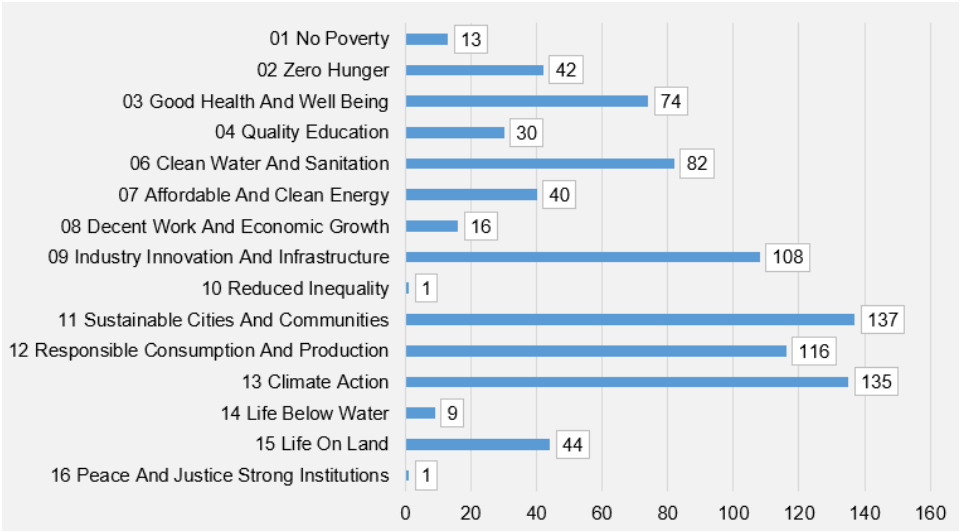


Source: Authors, based on WoS data

As regards the UN Sustainable Development Goals (SDGs) (Figure 4), two of three articles (66.98%) are associated with one of the following (SDGs making the top five): 11 Sustainable Cities and Communities, 13 Climate Action, 12 Responsible Consumption and Production, 09 Industry Innovation and Infrastructure, and 06 Clean Water and Sanitation. More than a quarter of the articles (26.65%) are associated with one of the following five SDGs: 03 Good Health and Well Being, 15 Life on Land, 02 Zero Hunger, 07 Affordable and Clean Energy, and 04 Quality Education. About five percent of the articles (4.64%) tackle one of the following SDGs: 08 Decent Work and Economic Growth, 01 No Poverty, 14 Life Below Water, 16 Peace and Justice Strong Institutions, and 10 Reduced Inequality.

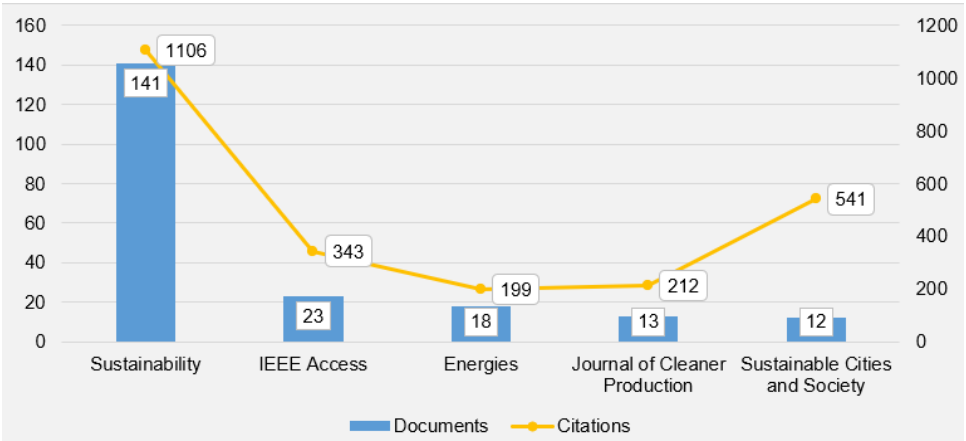
There are 434 sources/publications hosting the 863 documents, the Top 5 Source Titles - by Documents (Figure 5) being the following: Sustainability (Publisher: MDPI), IEEE Access (Publisher: The Institute of Electrical and Electronics Engineers), Energies (Publisher: MDPI), Journal of Cleaner Production (Publisher: Elsevier), and Sustainable Cities and Society (Publisher: Elsevier). Together, they represent about 1% of all sources (1.15%) and comprise almost one quarter of all documents (23.99%), while collecting almost one quarter of all citations (23.66%) that the 863 articles received over the 2018-2022 analyzed period. A (second) group of 51 journals (11.75% of all sources) – publishing between 3 and 11 articles each – is hosting 234 documents (27.11% of all documents), while 387 journals (87.10% of all sources) – publishing either one or two articles each – are hosting 422 documents (48.90% of all documents).

Figure 4. SDGs (records, of 863*)



208 records (24.102%) do not contain data in the field being analyzed
Source: Authors, based on WoS data

Figure 5. Top 5 Source Titles – by documents



Source: Authors, based on WoS data

If considering all the documents and their citations (till the moment the data have been collected / exported from WoS) (Table 2):

- 56 articles (representing 6.49% of all articles) are single-authored and 807 (93.51%) are co-authored; of the co-authored documents: 133 (15.41% of all articles) have 2 authors, 141 (16.34%) have 3 authors, 171 (19.81%) have 4 authors, 127 (14.72%) have 5 authors, 207 (23.99%) have between 6 and 10 authors, 21 articles (2.43%) have between 11 and 20 authors, and 7 (0.81%) have more than 26 authors;
- 7 authors (representing 0.19% of all authors) are the most prolific ones, having contributed to 5 articles each: Shivam Gupta (269 citations), Surajit Bag (261 citations), Ming-Lang Tseng (223 citations), Zaher Mundher Yaseen (141 citations), Amir Mosavi (74 citations), Anita Gehlot (44 citations), and Rajesh Singh (44 citations);

- 766 documents (representing almost 90% of all articles) have been cited at least once; together, they accumulated 14113 citations – making an average of 18.42 citations per cited document and a h-index of 54 (57 documents being cited 54 times or more).

Table 2. Summary of Performance Analysis

Unit of analysis	Total	Cited minimum once	Top 5 Most cited
Documents	863	766 (88.76%)	(Jiang & Wen, 2020) (378 citations) (Allam & Dhunny, 2019) (313 citations) (Wong et al., 2020) (253 citations) (Rajput & Singh, 2019) (242 citations) (Bag et al., 2021) (193 citations)
Sources	434	387 (89.17%)	Sustainability (141 documents / 1567 citations) International Journal of Information Management (5 documents / 750 citations) Sustainable Cities and Society (12 documents / 672 citations) IEEE Access (23 documents / 465 citations) Science of the Total Environment (11 documents / 454 citations)
Authors	3778	3418 (90.47%)	Jiang, Yangyang (1 document, 378 citations) Wen, Jun (1 document, 378 citations) Dieu Tien Bui (4 documents, 374 citations) Dwivedi, Yogesh K. (3 documents, 350 citations) Allam, Zaheer (1 document, 313 citations) Dhunny, Zaynah A. (1 document, 313 citations)
Organizations	1851	1695 (91.57%)	Islamic Azad University (Iran) Edith Cowan University (Australia) Ton Duc Thang University (Vietnam) Duy Tan University (Vietnam) Indian Institute of Technology Delhi (India)
Countries/Regions	92	91 (98.91%)	China, USA, India, Australia, England

Source: Authors, based on WoS data

3.2. Science Mapping and Visualization

3.2.1. Citation analysis

21 documents (representing less than 3% of all articles) have been cited more than 100 times; together, they have received almost a quarter of all citations (3406 citations). Of them, the Top 10 Most Cited Articles (Table 3), representing 1.16% of all documents, have collectively received about 15% of all citations (2138).

Table 3. Top 10 Most Cited Articles

Author(s), Year	Publication Title	Source Title
(Jiang & Wen, 2020)	Effects of COVID-19 on hotel marketing and management: a perspective article	International Journal of Contemporary Hospitality Management
(Allam & Dhunny, 2019)	On big data, artificial intelligence and smart cities	Cities
(Wong et al., 2020)	Time to seize the digital evolution: Adoption of blockchain in operations and supply chain management among Malaysian SMEs	International Journal of Information Management
(Rajput & Singh, 2019)	Connecting circular economy and industry 4.0	International Journal of Information Management
(Bag et al., 2021)	Role of institutional pressures and resources in the adoption of big data analytics powered artificial intelligence, sustainable manufacturing practices and circular economy capabilities	Technological Forecasting and Social Change
(Singh et al., 2020)	Convergence of blockchain and artificial intelligence in IoT network for the sustainable smart city	Sustainable Cities and Society
(Dincer & Acar, 2018)	Smart energy solutions with hydrogen options	International Journal of Hydrogen Energy
(Ahad et al., 2020)	Enabling technologies and sustainable smart cities	Sustainable Cities and Society
(Alsamhi et al., 2019)	Survey on Collaborative Smart Drones and Internet of Things for Improving Smartness of Smart Cities	IEEE Access
(Xiang et al., 2021)	Urban water resource management for sustainable environment planning using artificial intelligence techniques	Environmental Impact Assessment Review

Source: Authors, based on WoS data and using VOSviewer

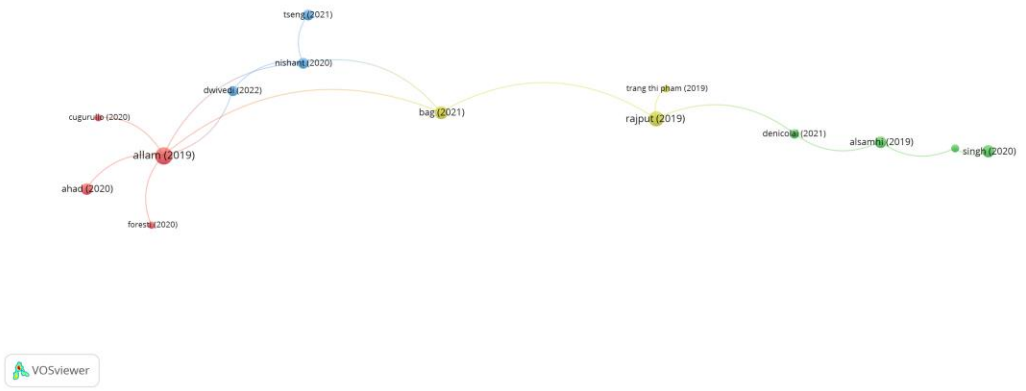
If considering the direct citations between the 57 documents reaching the 54 h-index, the largest set of connected items consists of 14 documents. These documents are grouped in four clusters (Figure 6) comprising the following articles:

- Cluster 1 (red - 4 items): "*On big data, artificial intelligence and smart cities*" (Allam & Dhunny, 2019), "*Enabling technologies and sustainable smart cities*" (Ahad et al., 2020), "*Urban Artificial Intelligence: From Automation to Autonomy in the Smart City*" (Cugurullo, 2020), "*Smart Society and Artificial Intelligence: Big Data Scheduling and the Global Standard Method Applied to Smart Maintenance*" (Foresti et al., 2020);
- Cluster 2 (green - 4 items): "*Convergence of blockchain and artificial intelligence in IoT network for the sustainable smart city*" (Singh et al., 2020), "*Survey on Collaborative Smart Drones and Internet of Things for Improving Smartness of Smart Cities*" (Alsamhi et al., 2019), "*Internationalization, digitalization, and sustainability: Are SMEs ready? A survey on synergies and substituting effects among growth paths*" (Denicolai et al., 2021), "*Drones' Edge Intelligence Over Smart Environments in B5G: Blockchain and Federated Learning Synergy*" (Alsamhi et al., 2022);

- Cluster 3 (blue - 3 items): "*Artificial intelligence for sustainability: Challenges, opportunities, and a research agenda*" (Nishant et al., 2020), "*Sustainable industrial and operation engineering trends and challenges Toward Industry 4.0: a data driven analysis*" (Tseng et al., 2021), "*Climate change and COP26: Are digital technologies and information management part of the problem or the solution? An editorial reflection and call to action*" (Y. Dwivedi et al., 2022);
- Cluster 4 (yellow - 3 items): "*Connecting circular economy and industry 4.0*" (Rajput & Singh, 2019), "*Role of institutional pressures and resources in the adoption of big data analytics powered artificial intelligence, sustainable manufacturing practices and circular economy capabilities*" (Bag et al., 2021), "*Industry 4.0 to Accelerate the Circular Economy: A Case Study of Electric Scooter Sharing*" (Pham et al., 2019).

Only six of the articles from the Citation Map are among the Top 10 Most Cited Articles: (Allam & Dhunny, 2019), (Rajput & Singh, 2019), (Bag et al., 2021), (Singh et al., 2020), (Ahad et al., 2020), and (Alsamhi et al., 2019).

Figure 6. Citation Map



Source: Authors, based on WoS data and using VOSviewer

3.2.2. Co-citation analysis

Of the 57488 cited references, 43 met the threshold set at 10 citations. After 6 citations with a total link strength below 10 were removed, the examined set consisted of 37 sources/documents; 18 of the documents were published before 2018, while 19 documents were published between 2018 and 2021. The 37 sources are grouped in 4 clusters (Figure 7), led by the following most representative publications (considering their total link strength):

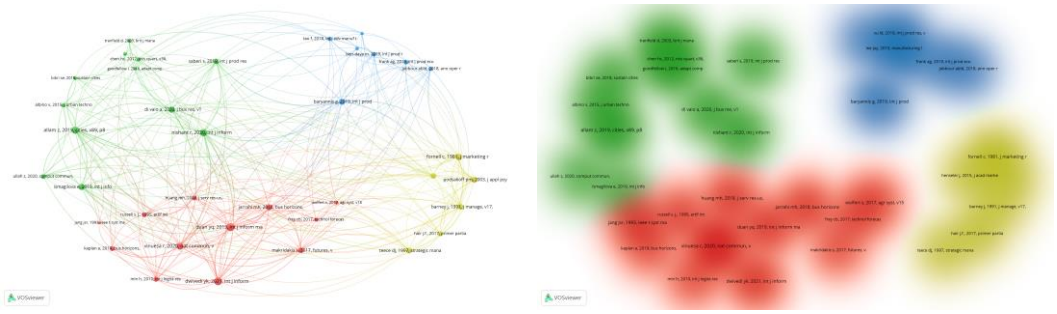
- Cluster 1 (red - 12 documents): "*Artificial Intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy*" (Y. K. Dwivedi et al., 2021); other relevant topics (given the documents' total link

strength): *AI for decision making* (Duan et al., 2019), *AI and SGDs* (Vinuesa et al., 2020), *AI and the future of work* (Jarrahi, 2018);

- Cluster 2 (green - 12 documents): "*On big data, artificial intelligence and smart cities*" (Allam & Dhunny, 2019); other relevant topics: *AI for sustainability* (Nishant et al., 2020), *smart cities* (Ismagilova et al., 2019), *AI and business models in the SDGs perspective* (Di Vaio et al., 2020);
- Cluster 3 (blue - 7 documents): "*Supply chain risk management and artificial intelligence: state of the art and future research directions*" (Baryannis et al., 2019); other relevant topics: *Industry 4.0 technologies* (Frank et al., 2019), *IoT and supply chain management* (Ben-Daya et al., 2019), *Industry 4.0 and the circular economy* (Lopes de Sousa Jabbour et al., 2018);
- Cluster 4 (yellow - 6 documents): "*Evaluating Structural Equation Models with Unobservable Variables and Measurement Error*" (Fornell & Larcker, 1981); other relevant topics: *method biases in behavioral research* (Podsakoff et al., 2003), *firm resources and sustained competitive advantage* (Barney, 1991), *dynamic capabilities and strategic management* (Teece et al., 1997).

Figure 7. Co-citation Map

a) Network visualization* b) Density visualization*



*Weights: Total link strength *Weights: Citations

Source: Authors, based on WoS data and using VOSviewer

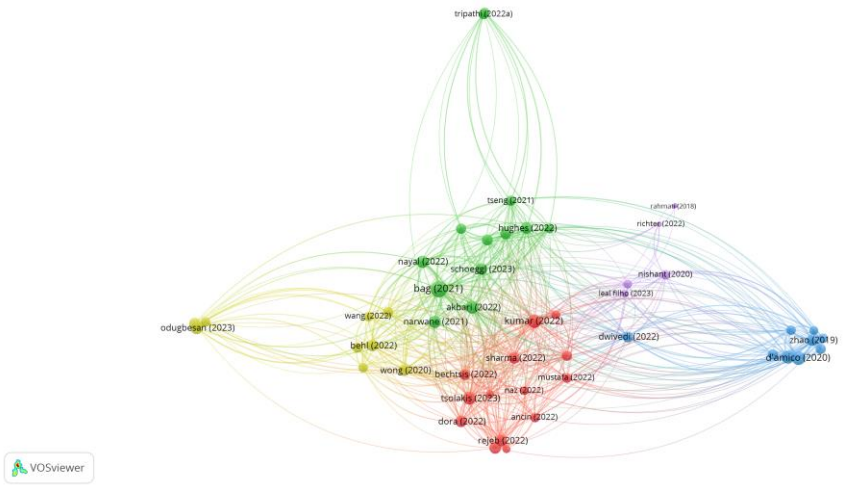
3.2.3. Bibliographic coupling

Of the 863 documents, 521 met the threshold set at 5 citations. For each of them, the total strength of the bibliometric coupling links has been calculated. Of the documents with the greatest total link strength, 52 documents (10%) have been selected; after removing one document (due to its below 10 total link strength), 51 documents remained. These articles are grouped in five clusters (Figure 8), each being defined by the following number-color-composition, research topic, and representative works:

- Cluster 1 (red - 14 items) – *(sustainable) supply chains through digitalization/AI* (Kumar & Barua, 2022), (Rejeb et al., 2022), (Bechtsis et al., 2022), (Tsolakis et al., 2023);

- Cluster 2 (green - 13 items) – *digital technologies for industry 4.0, sustainable manufacturing and circular economy* (Bag et al., 2021), (Tseng et al., 2021), (Nayal et al., 2022), (Chang et al., 2022) (Tripathi et al., 2022);
- Cluster 3 (blue - 9 items) – *(sustainable) smart cities* (Allam & Dhunny, 2019), (L. Zhao et al., 2019), (Ahad et al., 2020), (D'Amico et al., 2020);
- Cluster 4 (yellow - 9 items) – *(organizational talent) management and leadership for sustainable competitive advantage* (Ogbeibu et al., 2022), (Behl et al., 2022), (Chatterjee et al., 2022), (Odugbesan et al., 2023);
- Cluster 5 (violet - 6 items) – *AI and modeling for sustainability/sustainable development/SDGs* (Rahmati et al., 2018), (Nishant et al., 2020), (Palomares et al., 2021), (Leal et al., 2023).

Figure 8. Bibliographic Coupling Map*



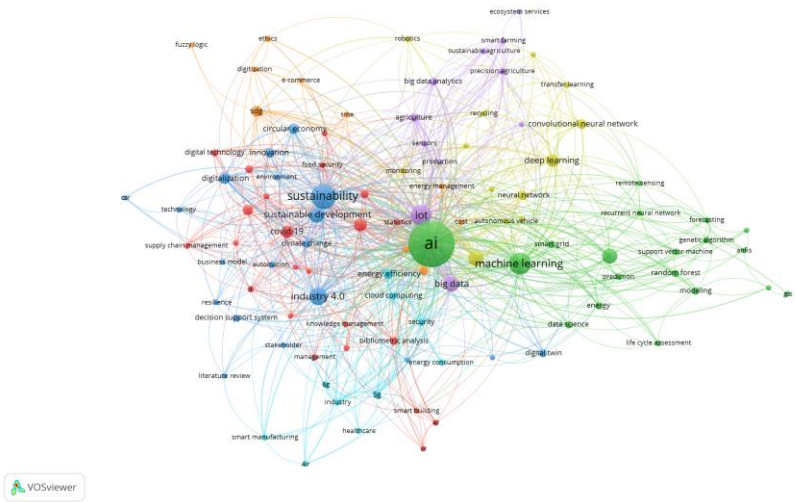
*Weights: Total link strength

Source: Authors, based on WoS data and using VOSviewer

3.2.4. Co-occurrence of (authors) keywords

Of the 3232 Author keywords (counted after the integration of the thesaurus file), 105 met the threshold of minimum 5 occurrences; all of them were selected for analysis. Setting at 10 the minimum cluster size, seven clusters emerged (Figure 9 and Table 4), led by the following (most frequently used) keywords: *blockchain, AI, sustainability, smart city, IoT, energy efficiency, and SDG*.

Figure 9. Co-occurrence of Author Keywords Map – Network Visualization



Source: Authors, based on WoS data and using VOSviewer

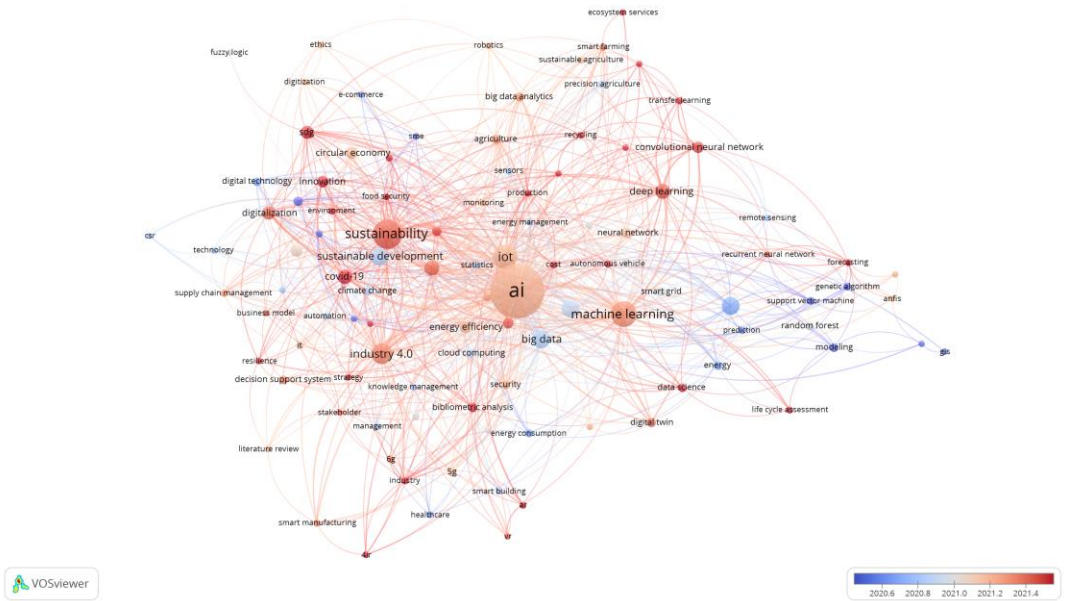
Table 4. Co-occurrence of Author Keywords – Clusters' Composition

Clusters	Items
1 Red (23 items)	**Blockchain**, Covid-19, digital transformation, renewable energy, bibliometric analysis, decision-making, digital technology, IT, supply chain management, AR, data analytics, food security, knowledge management, management, reinforcement learning, risk management, Covid-19 pandemic, data mining, information management, smart building, statistics, strategy, VR
2 Green (19 items)	**AI**, machine learning, artificial neural network, smart grid, data science, energy, modelling, random forest, genetic algorithm, prediction, support vector machine, forecasting, life cycle assessment, ANFIS, GIS, recurrent neural network, remote sensing, soft computing, water quality index
3 Blue (19 items)	**Sustainability**, industry 4.0, sustainable development, digitalization, circular economy, innovation, digital twin, climate change, decision support system, automation, technology, environment, business model, CSR, intelligent system, literature review, resilience, stakeholder, technological innovation
6 Yellow (13 items)	**Smart city**, deep learning, convolutional neural network, neural network, recycling, autonomous vehicle, robotics, transfer learning, biological system modelling, computer vision, monitoring, safety, waste management
5 Violet (11 items)	**IoT**, big data, agriculture, big data analytics, precision agriculture, sensors, production, smart farming, sustainable agriculture, ecosystem services, sentiment analysis
6 Cyan (10 items)	**Energy efficiency**, 5g, cloud computing, security, energy consumption, industry, 6g, smart manufacturing, fourth industrial revolution, healthcare
7 Orange (10 items)	**SDG**, optimization, resource management, cost, ethics, digitization, e-commerce, energy management, fuzzy logic, SME

Source: Authors, based on WoS data and using VOSviewer

The Overlay Visualization of the Co-occurrence of the Author Keywords Map (Figure 10) provides a dynamic view of the interactions between AI and sustainability against a business/management context – as reflected in literature. Moreover, the average publication year associated to each of the 105 keywords allows for the identification of the most actual items/topics (N.B. the closer to red an item is, the more recent it is). Thus, the most recent sets of keywords (according to their average publication year) are: *augmented reality, autonomous vehicle, Covid-19, life cycle assessment, production, reinforcement learning, SDG(s)* (average publication year: 2021.50), *data science, industry(ies), bibliometric analysis, forth industrial revolution, sentiment analysis, cost, innovation* (average publication year: between 2021.56 and 2021.67), *forecasting, recycling, computer vision, resilience, waste management* (average publication year: between 2021.71 and 2021.80), and *ecosystem services, environment, food security, information management, strategy, transfer learning* (average publication year: 2022.00).

Figure 10. Co-occurrence of Author Keywords Map – Overlay Visualization



Source: Authors, based on WoS data and using VOSviewer

4. Conclusions

The main conclusions of the bibliometric analysis may be summarized as follows:

- the academic community is increasingly interested in exploring the interrelations between AI and sustainability in a business and/or management context – a boost in documents and citations during the analyzed timespan (2018-2022) backing this assessment;
- two out of three articles are published in journals assigned to three WoS categories – i.e., Environmental Sciences, Green & Sustainable Science & Technology, and Environmental Studies;

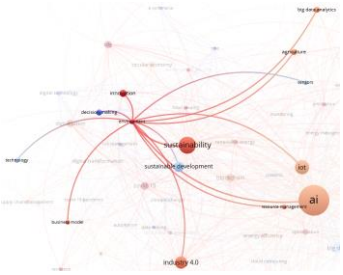
- Environmental Sciences & Ecology, Engineering, Science & Technology Other Topics, Computer Science, and Business & Economics are the most common Research Areas the articles fall under;
- two of three articles are associated with one of the following (SDGs making the top five): 11 Sustainable Cities and Communities, 13 Climate Action, 12 Responsible Consumption and Production, 09 Industry Innovation and Infrastructure, and 06 Clean Water and Sanitation;
- the top 5 source titles (by documents) are Sustainability, IEEE Access, Energies, Journal of Cleaner Production, and Sustainable Cities and Society; together, they represent about 1% of all sources and comprise almost one quarter of all documents, while collecting almost one quarter of all citations;
- the citation analysis revealed the following driving topics (related to AI and sustainability in a business/management context): big data (analytics), blockchain, IoT, smart drones, (sustainable) smart city, smart society, smart maintenance, climate change, circular economy, smart environments, industry 4.0, sustainable manufacturing;
- the co-citation analysis unveiled the following most significant antecedent topics/ideas contributing to the emergence of a new interest area at the intersection between AI and sustainability: multidisciplinary AI (AI for decision making, AI and SGDs, AI and the future of work, AI and smart cities, AI for sustainability, AI and business models, AI and supply chain risk management), Industry 4.0 (its technologies, relations to the circular economy, IoT and supply chain management), methodology related topics (structural equation models, method biases), (strategic) management fundamentals (firm resources, sustained competitive advantage, dynamic capabilities);
- the bibliographic coupling analysis led to the following clusters / main research topics of the examined articles: (sustainable) supply chains through digitalization/AI, digital technologies for industry 4.0, sustainable manufacturing and circular economy, (sustainable) smart cities, (organizational talent) management and leadership for sustainable competitive advantage, AI and modeling for sustainability/sustainable development/SDGs;
- the co-occurrence of authors keywords analysis confirmed the above results, while exhibiting the following threads of research: digital transformation through **blockchain** during covid-19, **AI** and machine learning – modelling and forecasting, **sustainability** and industry 4.0 for sustainable development, deep learning and recycling for **smart cities,** IoT and big data for (precision/smart/sustainable) **farming/agriculture,** cloud computing and 5g for **energy efficiency,** resource management optimization for the **SDG**(s).

As regards the **Trending Topics and Areas for Future Research** (Figure 11), the six keywords having 2022 as average publication year may be grouped as follows: Information management & Strategy, Transfer learning & Ecosystem services, Environment and Food security.

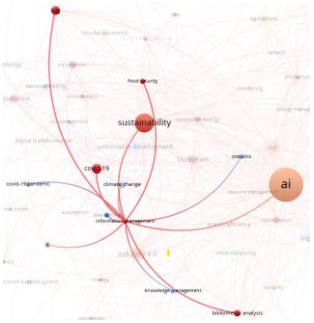
Figure 11. Trending Topics and Areas for Future Research



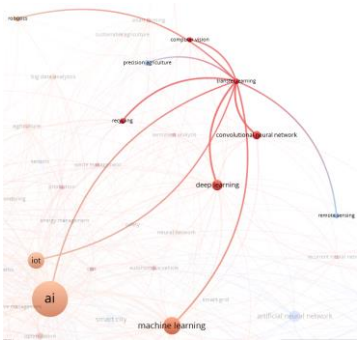
Food security
(linked with: sustainability, reinforcement learning, renewable energy, blockchain, covid-19, climate change, IoT, AI, agriculture, information management, digitalization, machine learning, big data)



Environment
(linked with: innovation, decision making, sustainability, sustainable development, technology, business model, industry 4.0, resource management, sensors, agriculture, IoT, big data analytics, AI)



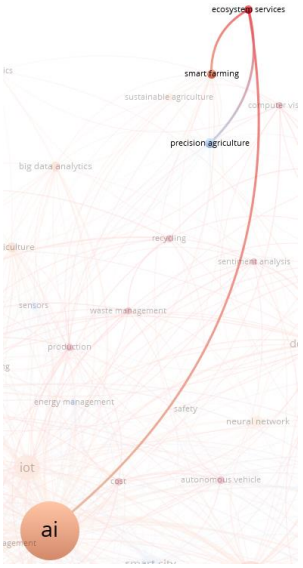
Information management
(linked with: data mining, climate change, Covid-19, IT, sustainability, food security, knowledge management, AI, Covid-19 pandemic, statistics, bibliometric analysis, SDG)



Transfer learning
(linked with: computer vision, convolutional neural network, precision agriculture, recycling, deep learning, remote sensing, machine learning, robotics, IoT, AI)



Strategy
(linked with: industry 4.0, management, IT, bibliometric analysis, energy efficiency, optimization, blockchain, renewable energy, IoT, AI, digital transformation, supply chain management)



Ecosystem services
(linked with: smart farming, precision agriculture, AI)

Source: Authors, based on WoS data and using VOSviewer

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