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Implementation of Artificial Intelligence Systems for Agri-food Supply Chains: A Bibliometric Approach

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Abstract

Purpose: The present study is developed with the aim of mapping the trends in scientific production related to the implementation of artificial intelligence systems for agro-food supply chains. **Research design, data and methodology:** The methodological approach of the research shows a descriptive documentary process based on bibliometric techniques for mapping the main indicators of the area of knowledge through the establishment of a search equation in Scopus. **Results:** The research results show a total of 633 documents published between 2019 and 2023, with a great annual growth rate of 61.68%; In addition to a notable participation of countries such as India, China, the United Kingdom and the United States in the generation of new knowledge related to artificial intelligence applied to food distribution systems. **Conclusions:** It is concluded that the rise of new artificial intelligence technologies has shown extremely important results in the development of industries worldwide, with increasingly accelerated steps; which certainly translates into the creation of spaces and incentives in the production of research aimed at understanding these dynamics and in turn to propose new alternatives and proposals for the reduction of the large technological gaps that are present within the agro-food sector.

Keywords: Artificial Intelligence, Agriculture, Supply Chain, Deep Learning, Agroindustrial

JEL Classification Code: O13, O14, O32, O33, J43, L86

1. Introduction

Within the framework of the Sustainable Development Goals, signed in 2015, a total of 17 objectives and 167 goals are stipulated, focused on the implementation of an articulated global agenda that allows responding to the needs of contemporary humanity (Blesh et al., 2019). These objectives mean a paradigmatic change, affecting all industries and sectors who see themselves as duty-bound not to be left behind in the modernization of their strategy towards contributing to this process promoted by UNESCO (Mochizuki, 2019).

In this sense, mention should be made of SDG number two of Zero Hunger; which is directed towards the implementation of strategies that allow optimizing production models worldwide so that inequalities in access

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to food can be reduced, reducing levels of malnutrition in the most vulnerable areas and regions (Byerlee & Fanzo, 2019). This framework reveals a high level of relevance of the agri-food sector in achieving this objective, because it is responsible for the generation of optimal production systems that can allow access to food for all humanity (Wongnaa & Awunyo-Vitor, 2018; Sridhar et al., 2023).

However, in recognizing the importance of the agri-food sector worldwide, it must be mentioned that it currently presents a large number of challenges which have not allowed us to achieve this objective in an optimal way, which dates back much earlier. of the appearance of the 2030 agenda, but has been a problem as old as contemporary society itself (Atukunda et al., 2021).

In this way, among the main challenges faced by the agri-food sector is climate change as a catalyst effect of various problems in the process of sustainability of agricultural production, such as major droughts, heat waves, changes in seasonal seasons within various territories, among others (Chemura et al., 2020). At the same time, the high levels of contamination present in ecosystems worldwide from other industries must be mentioned, giving rise to the entry of so-called emerging contaminants; which have been shown to negatively affect the quality of water resources for the sector and therefore, contaminating all products in the sector from meat to fruits, vegetables, among others (Singh et al., 2020; Singh et al., 2021).

Likewise, not only the presence of pollutants from other sectors should be mentioned, since it has also been proven through scientific research that the agricultural sector generates 38% of the total input of phosphorus to bodies of water at the worldwide level (Zou et al., 2022). This sector has certainly been identified for its great impacts on ecosystems and generation of greenhouse gases; thus showing the importance of determining tools and techniques that allow not only to respond to sustainable development through the elimination of hunger worldwide, but also guaranteeing environmental conditions through friendly and sustainable production systems (El-Ramady et al., 2022).

Some of the most notable challenges within the framework of the sustainability of the sector are related to optimal food distribution systems, which allow time and costs to be controlled in the logistics process (Sharma et al., 2017); so as to guarantee the distribution of farm products to various large and small surfaces to final consumers in all parts of the world. This panorama then requires the implementation of new technologies as tools to achieve the efficiency and effectiveness of agri-food distribution systems (Amentae & Gebresenbet, 2021). It is here that the technologies of industry 4.0 are mentioned, which through the integration of computer systems with the tasks of the industry would allow both the productive and distribution processes of the sector to be optimized to their maximum expression (Yadav et al., 2022).

Among these technologies, it is recognized that artificial intelligence is one of the crucial pieces in the generation of the agri-food sector, since it allows us to understand in an increasingly agile way the macro variables that affect the yields in the production and distribution systems of the sector (Taneja et al., 2023). Various studies, such as that of Monteiro and Barata (2021), show the great opportunities provided by the implementation of artificial intelligence, especially those related to the integration of various information systems and decision making.

However, it should be mentioned that the implementation of this technology is still very new with respect to other economic sectors; even more so when the large technological gaps faced by agribusinesses worldwide are understood, most of which do not apply precision agriculture due to lack of opportunities or lack of knowledge about these tools (Khanal et al., 2018; Naranjo, 2022). In contrast, it is possible to identify how the vast majority of agribusiness products worldwide (%) are made in a traditional way, without taking advantage of various technologies such as irrigation, crop planning, among others. This reality presents a complex panorama in the implementation of artificial intelligence within the sector, especially when it is identified that in developing countries, agriculture is carried out for subsistence and in an uneven manner; making it difficult to apply effective algorithms to diagnose the status of the sector in said nations.

At this point, the need for the approach of this study is revealed due to the importance of carrying out an arduous process of technological surveillance on the application of artificial intelligence systems for agro-food supply chains, thus generating a state of the robust and validated art through reliable scientometric tools in high-level scientific databases. This exercise then involves obtaining valuable secondary information for mapping the current state of scientific knowledge on this highly relevant topic today. In this way, based on what was explained previously, the present study is formulated with the aim of characterizing the trends in scientific production on the application of artificial intelligence systems for agri-food supply chains.

2. Literature Review

2.1. Innovation in the Agroindustrial Sector

To begin the analysis of innovation in the agroindustrial sector, the contributions of the OECD are cited with respect to the concept of innovation as “a new or improved product or process (or the combination of both), which differs significantly from existing products or previous processes of the unit and that has been made available to potential users (product), or put into use by the unit (Process)" (OECD, 2018, p. 20). It is from this conceptualization that it is possible to understand innovation as the integration of novel elements within the various products or processes in organizations, generating a factor of novelty and value for the actors who are linked to it (Umar & Safi, 2023; Henríquez-Calvo et al., 2024).

In this way, innovation is a condition and strategy implemented by organizations since it allows them to significantly increase their competitiveness through various dynamics (Haiyun et al., 2021), among which are: i) Research and Development Activities (R&D), ii) Engineering, design and other creative work activities, iii) Marketing and brand image activities, iv) Activities carried out with intellectual property, v) Training and training activities for employees, vi) Activities software and database development, vii) Activities related to the acquisition or leasing of tangible assets; and viii) Innovation management activities (OECD, 2018).

When applying this concept to the supply chains of the agroindustrial sector, it is important to understand that this happens through various phases and actors, which range from primary producers to transformation, collection centers, large sales areas in large cities and points of sale. of sale to the final consumer; happening many times in very short times considering the useful life of the farm products; and therefore, demanding a high level of agility throughout the entire process (Paciarotti & Torregiani, 2021). In this way, the supply chain today is perceived as a multi-agent and omnichannel organism; which through a series of agreements and coordination between each of the parties seeks to satisfy the needs of customers and maintain competitiveness within the market in the face of local or international competition (Zhang et al., 2022).

In this way, the agroindustrial sector has shown great progress in the implementation of 4.0 technologies in order to improve the levels of efficiency and effectiveness in both the production and distribution processes of agroindustrial products, maintaining, for example, the physical and production conditions. food safety so that they reach the final consumer in optimal conditions. This has brought the implementation of various technologies such as IOT, information systems based on Blockchain, Big Data or artificial intelligence; which have shown encouraging results for the entire industry (Pishdar & Habibi, 2023).

2.2. Artificial Intelligence

Artificial intelligence refers to a type of machine learning in which computers mimic human thought processes. Artificial intelligence facilitates the interpretation of data by computers, enabling them to learn and improve task development (Chen et al., 2020). AI may be defined as a branch of computer science that aims to develop systems that can mimic human intelligence. The following fields benefit from artificial intelligence's methods and applications: robotics, computer vision, neural networks, natural language processing, and machine learning (El-Komy et al., 2022).

The goal of artificial intelligence (AI), a multidisciplinary area of computing, is to imitate human thinking and learning processes in computer systems (Dwivedi et al., 2021). Artificial Intelligence (AI) enables robots to analyze data, see patterns, gain experience, and make decisions on their own using mathematical models and algorithms. This methodology introduces novel answers to intricate issues, transforming a multitude of industries, ranging from manufacturing to healthcare (Jan et al., 2023).

Natural language processing (NLP), which focuses on how computers and human language interact, is one of the most well-known subfields in artificial intelligence. Natural language processing (NLP) systems can comprehend, analyze, and produce text in a manner that is comparable to that of humans (Maulud et al., 2021). This capability has applications in machine translation, sentiment analysis on social media, and virtual assistants. The ability for people and machines to collaborate and communicate has been greatly enhanced by these developments in natural language processing (Meera & Gheerthik, 2022).

Computer vision, which focuses on creating systems that can automatically understand and analyze pictures and movies, is another significant area of artificial intelligence. These systems, which have uses in the security, medical, and entertainment sectors, employ image processing algorithms to detect objects, identify patterns, and monitor motions. Considerable progress has been made in domains like autonomous vehicle driving and illness detection from medical imaging thanks to computer vision (Zhou et al., 2021).

Neural networks are another fundamental technique in the field of AI, inspired by the functioning of the human brain. These computational models consist of interconnected layers of nodes, or artificial neurons, that process and transform data to perform specific tasks, such as pattern recognition, image classification, and text generation (Katal & Singh, 2022). Deep neural networks, also known as deep learning, have demonstrated exceptional performance in a variety of applications, including medical image processing, machine translation, and autonomous driving (Alam et al., 2020).

Machine learning is a key approach in AI that focuses on developing algorithms and models that can learn from data and improve their performance with experience. These algorithms can be supervised, unsupervised, or reinforcement, and are applied to a wide range of tasks, from sales prediction to email spam filtering (Sarker, 2021). Machine learning has driven significant advances in fields such as medicine, agriculture and astronomy, enabling large-scale data analysis and complex pattern discoveries (Ezugwu et al., 2023).

Robotics is another important application area of AI, combining mechanical engineering, electronics and computer science to design and build intelligent robots capable of autonomously performing tasks (Ness et al., 2023). These robots can be used in environments that are dangerous or inaccessible to humans, such as in space exploration or cleaning up environmental disasters. AI enables robots to adapt to changing environments, make decisions in real time, and collaborate with humans safely and efficiently (Soori et al., 2023).

In summary, artificial intelligence encompasses a wide variety of approaches and techniques that seek to replicate human intelligence in computer systems. From natural language processing and computer vision to neural networks and machine learning, AI is transforming the way humans interact with technology and opening up new opportunities in numerous fields (Ekman, 2021). With the continued advancement of research and innovation in this field, it is expected that artificial intelligence will continue to play a critical role in solving complex problems and improving the quality of life around the world (Xu et al., 2021).

2.3. Research Hypothesis

As previously said, the focus of this research's subject is innovation in the agroindustrial sector and how important it is for improving efficiency and competitiveness. This study emphasizes the complexity of innovation, taking into account supply chain dynamics, technology adoption, and R&D activities. It does this by drawing on OECD definitions and academic contributions (OECD, 2018). It also emphasizes how crucial it is becoming to use Industry 4.0 technologies—such as artificial intelligence—in order to boost productivity and innovation in agro-food supply chains.

On the other hand, the research's aim connects the mentioned ideas to artificial intelligence (AI), viewing it as a revolutionary technology with a wide range of applications in many fields. This study attempts to clarify the possibility of artificial intelligence (AI) imitating human intellect and transforming problem-solving techniques by providing a thorough analysis of AI subfields such as machine learning, computer vision, neural networks, and natural language processing (Chen et al., 2020). Furthermore, it's critical to emphasize how AI improves automation, data analysis, and decision-making across a range of industries, including food and farm production.

Expanding on the theoretical foundations previously established, the research hypothesis proposed for this study is the following: The integration of artificial intelligence (AI) technology in agri-food supply chains is an increasingly influential topic in the context of scientific production.

3. Research Methods and Materials

The empirical model supporting this bibliometric study is focused on examining the frequency and significance of publications about artificial intelligence in agro-food supply chains, based on the previously mentioned research hypothesis.

The empirical model of this research is structured as follows: 1) the collection and processing of data from pertinent sources using bibliometric tools (Galetsi & Katsaliaki, 2020), with an emphasis on papers that address artificial intelligence in the context of agro-food supply chains; 2) an examination of patterns in scientific output, such as growth rates for publications, document kinds, author collaboration patterns, and global contributions (Gosh et al., 2021); 3) applying Lotka's law to evaluate author productivity and contribution patterns (Sahu & Jena, 2022); 4) using Bradford's law to determine core journals and publication zones within the artificial intelligence in agro-food supply chains domain (Sudhier, 2020); 5) analyzing bibliometric indicators like source relevance, author affiliations, and citation patterns to determine the impact and visibility of research in this field (Orbay et al., 2021); and 6) using cluster analysis techniques to identify key terms and concepts related to artificial intelligence systems in agro-food supply chains, clarifying recurring themes and areas of interest for research (Dalmaijer et al., 2022).

The present study is formulated from the descriptive documentary approach, through the application of bibliometric tools for the capture and analysis of information regarding the implementation of artificial intelligence systems for agro-food supply chains. For this, the following variables are set with their descriptors.

Table 1: Keyword Standardization

Variable	Descriptor
Artificial intelligence	"Artificial intelligence" "Deep Learning"
Agro-food supply	"food" "agroindustrial" "agriculture" "agri-food" "supply chain" "logistics" "distribution process"

Source: Authors (2024).

Based on the identification of these elements, the following search equation is proposed in the Scopus database (TITLE-ABS-KEY ("artificial intelligence") OR

TITLE-ABS-KEY ("Deep Learning") AND TITLE-ABS - KEY ("food") OR TITLE-ABS-KEY ("agroindustrial") OR TITLE-ABS-KEY ("agriculture") OR TITLE-ABS-KEY ("agri-food") AND TITLE-ABS-KEY ("supply chain") OR TITLE-ABS-KEY ("logistics") OR TITLE-ABS-KEY ("distribution process")) With the data obtained from Scopus, a data analysis process is carried out with the support of the R software in its Bibliometrix package and VOS VIEWER software.

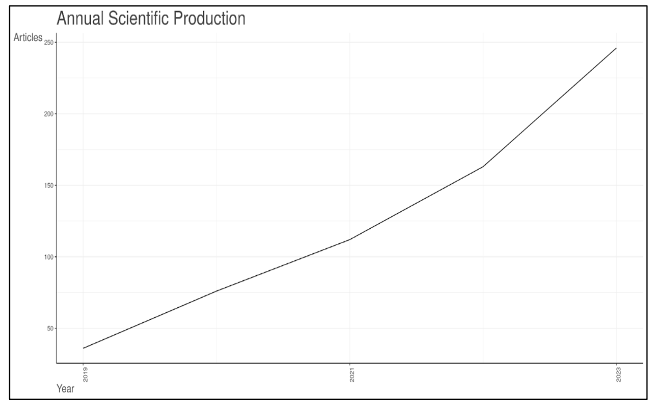
4. Results

Table 2: Main Information of the Data Obtained from Scopus.

MAIN INFORMATION ABOUT DATA	
Timespan	2019:2023
Sources (Journals, Books, etc)	422
Documents	633
Annual Growth Rate %	61,68
Document Average Age	2,2
Average citations per doc	14,01
References	27890
DOCUMENT CONTENTS	
Keywords Plus (ID)	3583
Author's Keywords (DE)	1757
AUTHORS	
Authors	2126
Authors of single-authored docs	36
AUTHORS COLLABORATION	
Single-authored docs	37
Co-Authors per Doc	3,81
International co-authorships %	26,07
DOCUMENT TYPES	
article	241
book	13
book chapter	73
conference paper	184
conference review	51
editorial	1
retracted	3
review	66
short survey	1

Source: Authors (2024).

The previous table (table 2) allows to identify the general elements associated with the scientific production of the area of knowledge, where a growth of 61.68% is observed in recent years, in a total of 633 sources with 2126 authors present in said sources. publications. Likewise, the growth of scientific production can be seen more clearly in figure 1; Of this, the years 2021 (112), 2022 (163) and 2023 of (246) articles each year stand out, in which there was a notable growth in publications related to the research topic, in these years 82.31% of all research carried out are concentrated.



Source: Authors (2024)

Figure 1: Annual scientific production,

4.1. Laws of Bibliometric Productivity

Lotka's law allows mapping the production curve on the N of authors to more clearly understand the impact of authors on the area of knowledge (Sahu & Jena, 2022). Regarding this, table 3 shows how 91% of the authors have made a single contribution, followed by 6.20% who have made at least two and the remaining 2.80% are divided equally between those who have made three contributions now. From the above it can be inferred that the majority of authors who investigate this topic are transitory.

Table 3: Lotka's Law

Written documents	No. of Authors	Ratio of authors
1	1935	0.910
2	131	0.062
3	33	0.016
4	23	0.011
5	2	0.001
6	1	0.000
7	1	0.000

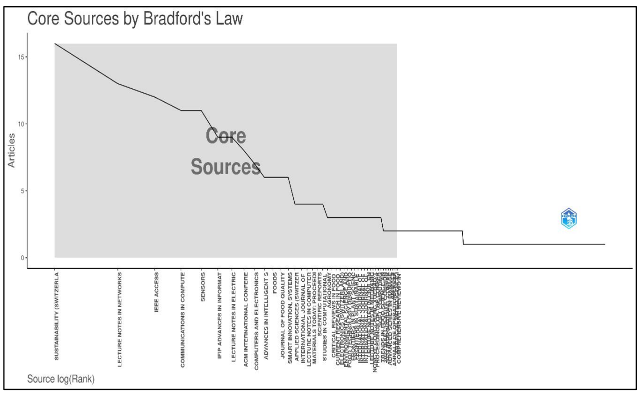
Source: Authors (2024).

The most relevant sources are shown based on the frequency of publication on the topic and through the percentiles shown through Bradford's law; This law classifies journals into three performance zones, each with an increase in the number of journals and a similar proportion of articles (Sudhier, 2020). Table 4 shows the percentages corresponding to each Bradford Law Zone. It should be noted that the zone is the one that concentrates the most publications with 33.02%, one hundred and seventyone (171) titles in forty-three (43) magazines. Figure 2 shows the most representative magazines according to this law.

Table 4: Bradford's Law.

Zone	No. Magazines	No. Titles	Percentages
Zone 1	43	171	33,02%
Zone 2	209	206	34,48%
Zone 3	208	208	32,86%

Source: Authors (2024).



Source: Authors (2024).

Figure 2: Bradford's Law

4.2. Bibliometric Indicators

Table 5 shows how Sustainability (Switzerland) leads the area with sixteen (16) Publications, followed by Lecture Notes In Networks And Systems with thirteen (13) publications and lastly Ieee Access with twelve (12) publications.

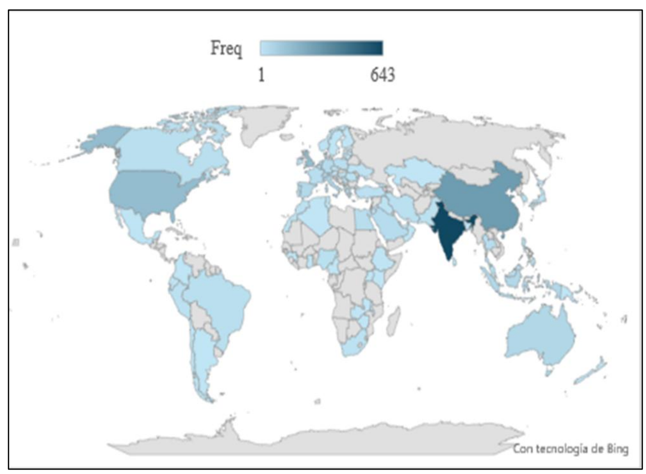
Table 5: Most Relevant Sources.

Sources	Articles
SUSTAINABILITY (SWITZERLAND)	16
LECTURE NOTES IN NETWORKS AND SYSTEMS	13
IEEE ACCESS	12
COMMUNICATIONS IN COMPUTER AND INFORMATION SCIENCE	11
SENSORS	11
IFIP ADVANCES IN INFORMATION AND COMMUNICATION TECHNOLOGY	9
LECTURE NOTES IN ELECTRICAL ENGINEERING	9
ACM INTERNATIONAL CONFERENCE PROCEEDING SERIES	8
COMPUTERS AND ELECTRONICS IN AGRICULTURE	7
ADVANCES IN INTELLIGENT SYSTEMS AND COMPUTING	6

Source: Authors (2024).

On the other hand, as can be seen in Figure 3, which represents 27.47% of the published papers, publications from India dominate the study field. Despite the fact that food logistics have been more effective over time, Industry 4.0 technologies have only just started to be implemented, according to one of the leading writers in that nation. The author claims that new methods for food logistics are needed in light of the present trend toward Industry 4.0 technology. These methods should lower carbon emissions and logistics costs while also enhancing overall sustainability (Jagtap, 2021).

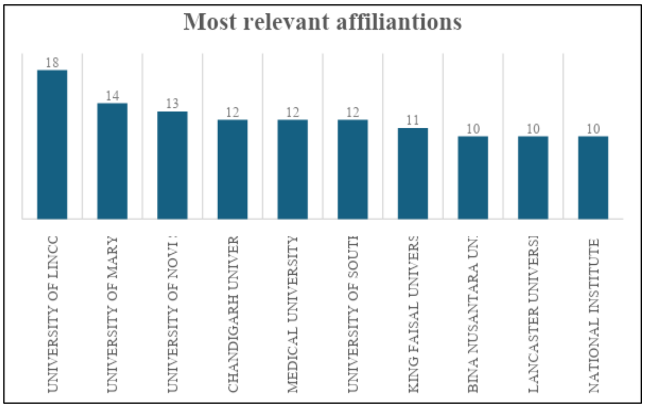
Another author discovered that for decades, the agricultural industry has been at the forefront of digital innovation, particularly in the areas of precision agriculture, robotics, remote sensing, agricultural management information systems, and (agronomic) decision support systems. Thanks to a widespread digital revolution in food and agriculture, all these technologies have been made possible (Pedro & Gonzales-Andújar, 2019).



Source: Authors (2024).

Figure 3: Scientific Production by Country

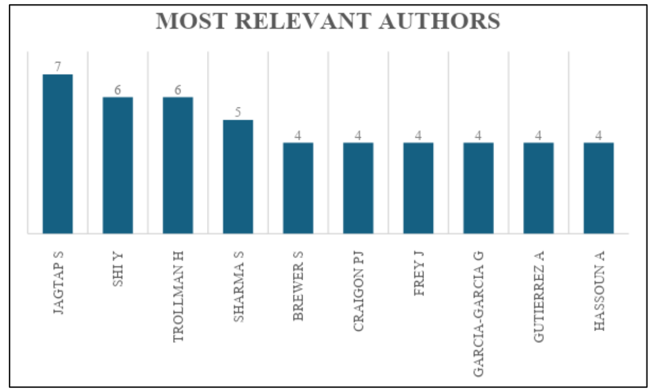
Following this order of ideas, figure 4 shows the institutions that have made the most contributions on the topic of study University of Lincoln with eighteen (18) contributions, followed by the University of Marlyland with fourteen (14) contributions and finally the University of Novi Sad with thirteen (13) contributions; These contribute 2.65% of all publications, taking into account that there are co-authored works between them.



Source: Authors (2024)

Figure 4: Most Relevant Affiliations

In another order of ideas, to measure productivity per researcher, the frequency index is taken as a reference; On which figure 5 shows the leadership of Jagtap S with seven (7) contributions followed by Shi Y and Trollman H with six contributions each.



Source: Authors (2024)

Figure 5: Most Relevant Authors

Finally, table 6 shows the twenty-five articles related to the topic of study that have the most citations; The three most representative are: LEZOCHE M, 2020, COMPUT IND, LIU Y, 2021, IEEE TRANS IND INF and ZHOU L, 2019, COMPR REV FOOD SCI FOOD SAF.

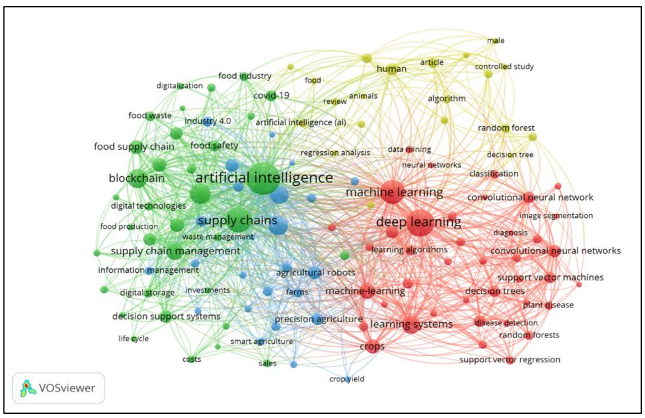
Table 4: Most Cited Articles.

Articles	DOI	Total Citations	TC per Year	Normalized TC
LEZOCHE M, 2020, COMPUT IND	10.1016/j.compind.2020.103187	380	76.00	8.80
LIU Y, 2021, IEEE TRANS IND INF	10.1109/TII.2020.3003910	320	80.00	21.14
ZHOU L, 2019, COMPR REV FOOD SCI FOOD SAF	10.1111/1541-4337.12492	290	48.33	8.13
AHAD MA, 2020, SUSTAINABLE CITIES SOC	10.1016/j.scs.2020.102301	288	57.60	6.67
MISRA NN, 2022, IEEE INTERNET THINGS J	10.1109/JIOT.2020.2998584	253	84.33	22.82
WAMBA SF, 2020, INT J INF MANAGE	10.1016/j.ijinfomgt.2019.102064	234	46.80	5.42
ANTONUCCI F, 2019, J SCI FOOD AGRIC	10.1002/jsfa.9912	217	36.17	6.08
MOOSAVI J, 2022, INT J DISASTER RISK REDUCT	10.1016/j.ijdrr.2022.102983	164	54.67	14.79
DI VAIO A, 2020, SUSTAINABILITY	10.3390/SU12124851	164	32.80	3.80
WANG S, 2020, REMOTE SENS	10.3390/rs12020207	161	32.20	3.73
DHAMIJA P, 2020, TQM J	10.1108/TQM-10-2019-0243	153	30.60	3.54
KHAN PW, 2020, SENSORS	10.3390/s20102990	149	29.80	3.45
ESPEJO-GARCIA B, 2020, COMPUT ELECTRON AGRIC	10.1016/j.compag.2020.105306	149	29.80	3.45
NHU V-H, 2020, INT J ENVIRON RES PUBLIC HEALTH	10.3390/ijerph17082749	145	29.00	3.36
GUO L, 2020, ADV MATER	10.1002/adma.202004805	141	28.20	3.27
WALLING E, 2020, J ENVIRON MANAGE	10.1016/j.jenvman.2020.111211	135	27.00	3.13
ALLAOUI H, 2019, J CLEAN PROD	10.1016/j.jclepro.2019.04.367	131	21.83	3.67
IWENDI C, 2020, IEEE ACCESS	10.1109/ACCESS.2020.2968537	127	25.40	2.94
CUBRIC M, 2020, TECHNOL SOC	10.1016/j.techsoc.2020.101257	126	25.20	2.92
SMITH MJ, 2019, ANI PROD SCI	10.1071/AN18522	117	19.50	3.28
HAMRANI A, 2020, SCI TOTAL ENVIRON	10.1016/j.scitotenv.2020.140338	98	19.60	2.27
JAVAID M, 2022, INT J INTELL NETW	10.1016/j.ijin.2022.09.004	94	31.33	8.48
KONG J, 2021, COMPUT ELECTRON AGRIC	10.1016/j.compag.2021.106134	94	23.50	6.21
BOTTANI E, 2019, COMPUT IND ENG	10.1016/j.cie.2019.05.011	91	15.17	2.55
JAGTAP S, 2021, LOGIST	10.3390/logistics5010002	83	20.75	5.48

Source: Authors (2024)

4.3. Analysis of Relationships and Co-occurrences

Finally, the cluster analysis through VOS VIEWER, figure 6 reveals the terms with the greatest impact grouped by co-occurrence, where it is observed as keywords such as "Agriculture", "Artificial Intelligence", "Machine Learning", "Deep Learning", "Supply Chains" and "Learning Systems" are several of the key terms associated with the area of knowledge of an implementation of artificial intelligence systems for agri-food supply chains.



Source: Authors (2024)

Figure 8: Co-occurrence of Keywords

5. Discussion and Implications

Of the 662 articles analyzed in this bibliometric study based on the information obtained from Scopus on the implementation of artificial intelligence systems for agri-food supply chains, it can be said that:

The highest peaks of publications occur in the years 2021, 2022 and 2023, where 82.31% of the total published works are concentrated. The scientific production analyzed in the period from 2020 to 2024 shows a growth rate of 61.68%. 68% of all publications are concentrated in India, China, UK, USA, Italy, Australia, Greece, Indonesia, Spain, Portugal. On the other hand, the journals that publish the most on the subject are, such as Sustainability (Switzerland) leading the area with sixteen (16) Publications, followed by Lecture Notes In Networks And Systems with thirteen (13) publications and finally Ieee Access with twelve (12) publications, the rest of the publications are dispersed among different magazines.

The institutions that have made the most contributions on the topic of study are evidence that the institutions that have made the most contributions on the topic of study are the University of Lincoln with eighteen (18) contributions, followed by the University of Marlyland with fourteen (14) contributions and by last University of Novi Sad with thirteen (13) contributions; These contribute 2.65% of all publications. The authors with the most published articles are Jagtap S with seven (7) contributions followed by Shi Y and Trollman H with six contributions each; This is taking into account that 26.07% of the researchers in this field are from international co-authorships. The keywords most related to the topic of study are "agriculture" "artificial intelligence" "machine learning" "Deep learning" "supply chains" "learning systems".

Once the conclusions of this study have been demonstrated, the process of contrasting the research findings with other international contributions is carried out. Within this exercise, Sharifmousavi et al. (2024) is cited, who through a process of integration of artificial intelligence, IOT and big data make it possible to demonstrate how these technologies allow increasing levels of autonomy, self-organization, self-optimization, self-adaptation, solidity and supply chain flexibility; making it self-sufficient in generating its value.

El Jaouhari and Hamidi (2024) for their part analyze the process of implementing AI within food sector supply chains from the perspective of business managers; based on the perspective of the challenges in the use of these new technologies within Moroccan organizations towards agri-food supply chain efficiency (AFSCE), Drawing on dynamic capability view (DCV) and distribution network efficiency (DNE) as an output of said system.

Zhong et al. (2024) for their part point out important relationships between the artificial intelligence index, the global supply chain indicator and the energy uncertainty index; evidencing a short, medium and long term relationship between these factors; showing how artificial intelligence has an important presence in supply chains and advances in energy issues, promoting innovation and resolution of needs. Divyashree et al. (2024) for their part show the important returns of the use of deep learning as an AI-based technology for the optimization of the food logistics chain; especially what is related to process efficiency and food safety through control and monitoring systems.

The study's findings also highlight the applicability and possible influence of artificial intelligence on supply chain optimization in the agri-food industry. These results are consistent with other studies that show how important AI, IoT, and big data are to enhancing supply chains' flexibility, efficiency, and autonomy. There are also studies that show how supply chain efficiency, artificial intelligence, and advancements in energy issues are related, as well as studies that examine the unique opportunities and challenges of implementing AI from the viewpoint of business managers. These findings emphasize how crucial it is to keep researching and creating artificial intelligence-based solutions to deal with present and upcoming issues in agri-food supply chains in order to increase the effectiveness, sustainability, and quality of food production and distribution on a global scale.

Similarly, pinpointing the primary publications, establishments, and writers in this area offers a more in-depth understanding of the dynamics of study and cooperation in the field of artificial intelligence utilized in agri-food supply chains. The diversity of the journals that publish on this subject, the prominence of specific authors and institutions, and the range and depth of knowledge gained in this field highlight the need of continuing to foster interdisciplinary collaboration and the dissemination of findings. All of these results emphasize how critical it is to keep researching and creating cutting-edge artificial intelligence-based solutions in order to enhance the resilience, sustainability, and efficiency of agri-food supply chains in a dynamically changing global environment.

6. Suggestions for Future Research and Limitations

Once this study is completed and the contrast process has been carried out with other research related to the topic of the Implementation of artificial intelligence systems for agro-food supply chains, it is possible to state the following limitations:

In the first instance, it is recognized that the novelty of the high diffusion of artificial intelligence technology worldwide translates into a high level of increase in scientific production within the area, but this shows very preliminary results regarding the real results that this has within the industry. The great reception of artificial intelligence within society in general has certainly set off alarm bells in the entire scientific community, as it is advancing by leaps and bounds day after day, but without clear implementation and regulation systems, but rather a current design exercise. and implementation of its applicability validated by empirical processes. It is therefore important to continue carrying out research that tracks the types of application and their real results within the agroindustrial sector.

Likewise, the high concentration of scientific production in developed countries is identified as a limitation, since this allows us to broadly demonstrate the technological gaps that exist between less industrialized countries and the powers; increasing the gaps in reducing hunger in the world and making it difficult for this study to clearly identify the applicability of this technology in more frugal innovation systems. It is then recommended to deepen the exercise of proposing studies on both research and development of industry 4.0 technologies to solve the challenges of the agricultural sector.

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