The Impact of Artificial Intelligence on Quality and Sustainable Development: A Bibliometric Analysis

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ABSTRACT

Purpose: This bibliometric study aims to analyse the impact of artificial intelligence (AI) on quality and sustainable development.

Methodology/Approach: The research employed the InOrdinatio method, complemented by R Studio and the Bibliometrix package, to conduct a comprehensive review of scientific publications from 2000 to 2024.

Findings: The results reveal a significant annual growth rate of 25% in scientific production, accumulating 925 documents. AI has been widely applied to optimise organisational quality processes, particularly in manufacturing and technology sectors. Furthermore, AI has contributed to sustainable development by enhancing resource management and promoting sustainable practices. The study highlights strong international collaboration, with China, the United States, and India leading scientific output.

Research Limitation/Implication: Despite the increasing convergence of AI, quality, and sustainability, the study identifies gaps in research integration across underrepresented regions and a lack of focus on emerging areas.

Originality/Value of paper: This study provides a structured bibliometric analysis, shedding light on the evolving role of AI in enhancing quality management and fostering sustainability. The findings contribute to future research directions by identifying key trends, challenges, and opportunities for innovation.

Category: Literature review

Keywords: quality; international collaboration; sustainable development; artificial intelligence; scientific production

Research Areas: Quality 4.0; Quality Management

1 INTRODUCTION

Artificial intelligence (AI) has emerged as one of the most disruptive and transformative technologies in the 21st century, significantly impacting multiple sectors of the economy. According to Haenlein et al. (2019); Mikalef and Krogstie (2020), AI encompasses systems capable of mimicking human cognitive functions, such as learning and problem-solving, which has enabled organisations to optimise processes and generate innovations in products and services. Over the past decade, there has been a notable increase in the adoption of AI in areas such as healthcare, education, and particularly in the manufacturing industry, where its implementation has driven automation and data-driven decision-making (Alhajeri and Alhashem, 2023). However, despite these advancements, debates persist regarding its ethical implications and its long-term impact on the labour market and technological governance (Yigitcanlar and Cugurullo, 2020).

On the other hand, quality, as a concept and managerial practice, has evolved substantially from its traditional conception of product control to a more comprehensive approach that involves all organisational processes (Amaya Pingo et al.,2020). Authors such as Crosby (1979); Deming (1982); Feigenbaum (1991), laid the groundwork for a modern vision of quality, highlighting the importance of continuous improvement, customer satisfaction, and employee empowerment. In recent decades, quality management has become a key factor for organisational success in competitive environments, due to its ability to improve efficiency and reduce costs (Silva-Ordoñez et al. 2019). With the incorporation of technologies such as AI, quality has found new opportunities to be managed more precisely and efficiently (Nguyen et al., 2018).

The concept of sustainable development has gained increasing relevance since the publication of the Brundtland Report in 1987, which defined sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (CEPAL, 2016). Authors such as Sachs 2015, have highlighted the importance of integrating economic, social, and environmental considerations into organisational decisions to ensure balanced and sustainable growth. In this sense, sustainable development has become a strategic priority for many organisations seeking not only financial success but also minimising negative impact on the environment and contributing to social well-being (Sharma and Kulshrestha, 2024)

The intersection between artificial intelligence, quality, and sustainable development has attracted the attention of researchers and professionals. According to recent studies (Verma et al., 2021; Murdan and Oree, 2024), AI provides innovative tools to improve quality management systems, contributing to sustainability goals such as waste reduction and efficient resource utilisation. Organisations implementing AI practices demonstrate a greater capacity to adapt to sustainability standards, optimising processes without compromising quality (Ponce-Diaz et al., 2024; Wani et al., 2024).

This convergence highlights the need to develop integrated strategies that address quality and sustainable development jointly through the use of AI, creating long-term value for society and the planet (Santos et al., 2024). This study contributes to the existing body of knowledge by providing a bibliometric analysis of this intersection, offering insights into key trends, influential authors, and emerging research areas. Furthermore, it presents a structured synthesis of how AI enhances quality management practices while fostering sustainable development, paving the way for future interdisciplinary research and practical applications.

This article is structured in five sections: the first introduces the intersection between artificial intelligence, quality, and sustainable development; the second details the materials and methods used, highlighting the InOrdinatio method and tools such as R Studio and Bibliometrix for bibliometric analysis; the third presents the results, focusing on key trends, influential authors, and international collaborations; the fourth discusses the findings regarding the impact of AI on quality management and sustainable practices, as well as the opportunities and challenges; and the fifth concludes with the practical implications, limitations of the study and potential future research lines.

2 METHODOLOGY

To conduct the bibliometric analysis of the impact of artificial intelligence on quality and sustainable development, the InOrdinatio method was employed, complemented by artificial intelligence (AI) tools, along with the use of R Studio software and the Bibliometrix package, which optimised the process of reviewing and classifying scientific articles. This approach enabled a rigorous and quantitative evaluation of the existing literature, providing a clear insight into the trends, contributions and research gaps in the field.

The process began with an exhaustive search in high-impact academic databases such as Scopus, Web of Science and Google Scholar, using keywords such as "artificial intelligence", "quality" and "sustainable development". Inclusion criteria were applied that restricted the articles to those published between 2000 and 2024 in scientific journals of technology, engineering, environmental sciences and organisational management, ensuring that the selected studies addressed the interrelationship of the three variables.

Next, the InOrdinatio method was applied, an algorithm that classifies articles based on three criteria: the journal impact factor, the number of citations and the year of publication. This method weighs the aforementioned factors to prioritise recent articles with high scientific relevance, ensuring that the most influential and current studies are positioned at the top of the list (Pagani et al., 2015). This ensured accuracy and objectivity in selecting the most valuable articles for analysis. As a search equation, the intersection of "artificial intelligence" AND "quality" AND "sustainable development" was established.

The analysis was enhanced through R Studio and the Bibliometrix package, specialised tools for bibliometric analysis. Bibliometrix managed and analysed the article database, providing metrics such as co-citation networks, keyword co-occurrence and collaboration between authors and institutions. These tools generated graphs and bibliometric network maps that identified the most researched areas, most cited authors and key publications.

R Studio and Bibliometrix facilitated the creation of graphs that visualised the connections between the predominant themes and the temporal evolution of the research. Furthermore, the use of artificial intelligence (AI), through natural language processing (NLP) algorithms, enabled the automatic analysis of article abstracts and keywords, identifying the main topics and evaluating the relevance of each study in relation to the research objectives (Chowdhary, 2020). AI also helped to detect co-citation networks, visualising the connections between the most influential authors and the most researched topics at the intersection of artificial intelligence, quality and sustainable development.

The results of the analysis were presented through bibliometric maps and graphs generated in R Studio, which clarified the main trends, authors and topics in the field. These findings provide a solid basis for identifying emerging areas of research and suggesting potential future directions for academic and applied studies.

3 RESULTS AND DISCUSSION

The results obtained through bibliometric analysis provide a detailed insight into the impact of artificial intelligence on quality and sustainable development. Using the InOrdinatio method, complemented by AI, R Studio, and Bibliometrics, the study identified the most relevant trends in the literature, the most cited authors, and emerging research areas at the intersection of these three variables. The data reveal not only the key publications that have shaped the development of this field but also the temporal evolution and connections between topics and authors. The most significant findings are presented in Table 1, illustrated through bibliometric graphs and co-citation maps, reflecting the current state and future research opportunities.

Table 1 – Summary of Bibliometric Information on the Impact of Artificial Intelligence on Quality and Sustainable Development (2000-2024)

Description	Results
Period	2000 – 2024
Sources	601
Total publications	925
Annual growth rate	25%
Average document age	3.17
Citations	13.0
Keywords	7,080
Authors	119

Description	Results
Co-authors per document	3.98
Co-authorship percentage	25.19%
Articles	374
Books	12
Book chapters	74
Conference papers	337
Reviews	18
Editorials	8
Errata	1
Letters	2
Notes	1

The bibliometric analysis of publications on the impact of artificial intelligence on quality and sustainable development between 2000 and 2024 reveals significant growth, with an annual rate of 25% and a total of 925 documents published. Articles constitute the largest percentage (374), followed by conference papers (337) and book chapters (74). The average age of the documents is 3.17 years, indicating that the literature is relatively recent, and each document receives an average of 13 citations, reflecting a considerable impact on the academic community. With over 7,080 keywords and 3.98 co-authors per document, strong collaboration between authors is evident, with 25.19% of international co-authorship, underlining the activity and collaboration at the intersection of artificial intelligence, quality and sustainability.

The bibliometric analysis shows exponential growth in research on artificial intelligence, quality and sustainable development, positioning the topic as an emerging and relevant area. The diversity of publication formats reflects a balance between theory and practice, highlighting the interdisciplinary and global nature of the field. The indicators evidence an active and dynamic academic ecosystem that generates up-to-date knowledge and promotes its practical application, consolidating this intersection as a key axis for innovation and sustainable development.

Publications by Year

The bibliometric analysis indicates a growing interest and relevance of the topic within the academic community, with a notable increase in publications since 2020. In particular, 225 documents were recorded in 2023, suggesting that the combination of artificial intelligence, quality and sustainability is an emerging field of great importance for research (Figure 1).

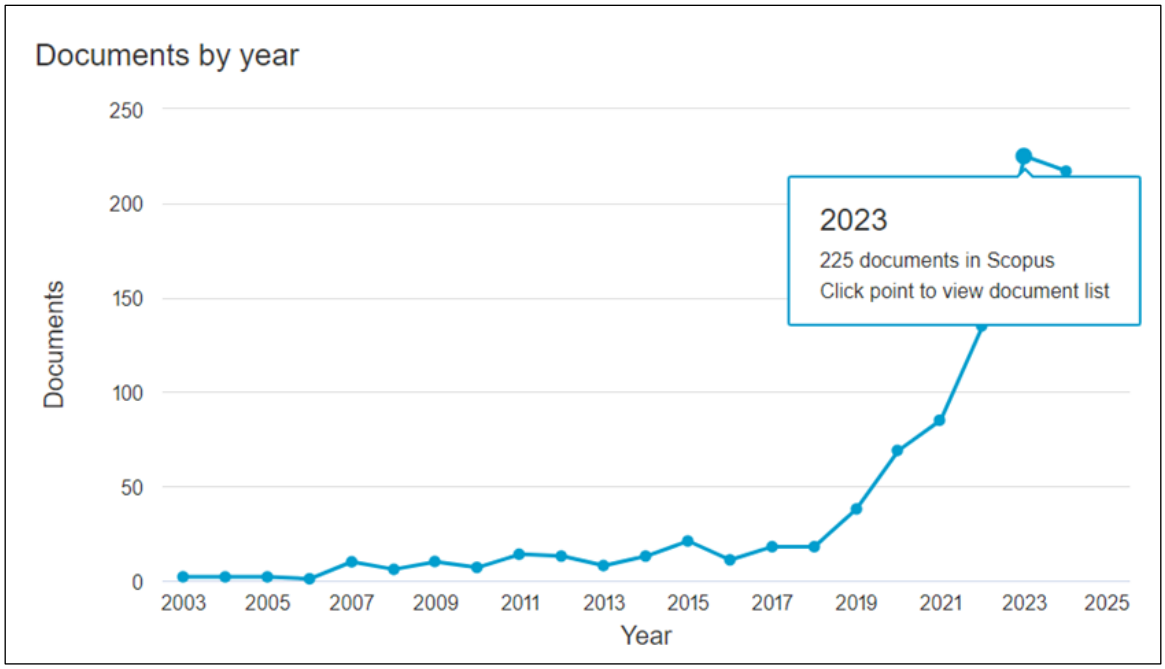

Figure 1 – Publications by Year

Throughout history, various events have influenced the development and evolution of artificial intelligence (AI) in scientific literature, affecting its progress and periods of stagnation (Qin et al., 2024). Scientific production in AI, quality management and sustainable development has varied according to the historical context. A notable example is World War II (1939-1945), which caused a decline in scientific publications globally. However, between 1972 and 1974, the scientific community showed a renewed interest in organisational management, human capital and technological development, laying the groundwork for the evolution of artificial intelligence (Haenlein et al., 2019; Quintero-Quintero et al., 2021).

Regarding quality, its conceptualisation has been evolving, particularly with the integration of information and communication technologies (ICT), which began to gain greater relevance from the 1950s onwards. During that period, theories on knowledge management and competency-based management began to emerge, underlining the importance of technology and continuous learning as key factors for gaining a competitive advantage in the new knowledge society (Popović, 2019).

During the 1980s, scientific production intensified due to the advancement of ICT and the emergence of the internet, which propelled the globalisation of knowledge and the creation of international networks. This advancement facilitated the connection between AI, quality management and sustainability principles, three variables that are now fundamental for economic growth and organisational innovation (Matyushok et al., 2021).

The bibliometric analysis highlights a growing academic interest in the intersection of artificial intelligence, quality and sustainable development, reflected in a

significant increase in publications. This growth underlines the consolidation of this field as emerging and crucial for research.

Evolution of Keywords

Keywords were analysed directly from the published documents, taking into account the frequency of occurrence of the most frequently used keywords. In Figure 2, it was possible to show that the 3 most used words are sustainable development and artificial intelligence with an average of 585.5, which is relevant when considering the study of this topic for higher education institutions, as it encompasses a wide variety of areas.

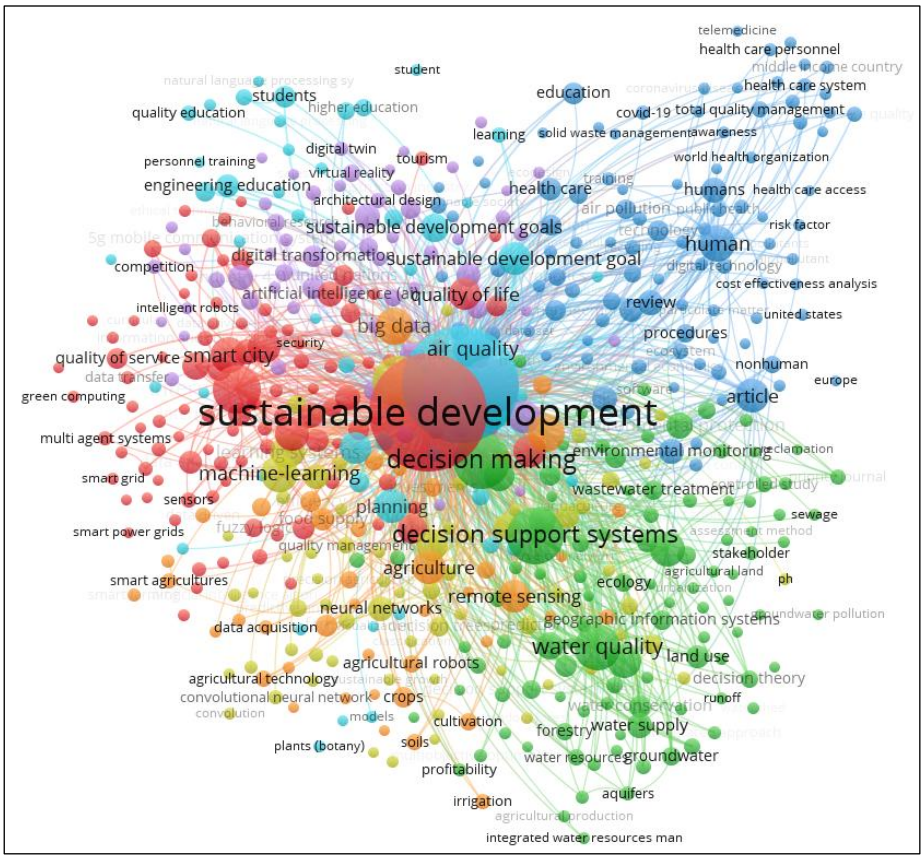

Figure 2 – Keyword Co-occurrence

Keyword co-occurrence clusters were identified, firstly, the Green Cluster – Agriculture and Natural Resources, which focuses on topics related to agriculture, water quality and natural resource management. AI plays a key role in this cluster by improving decision-making in sustainable agriculture and water quality management. Secondly, the Red Cluster – Smart Cities and Information Technologies, which groups terms such as smart city (machine learning city, big data, service quality). It is important to note that smart cities are not only connected to the use of AI, but also to the improvement of quality of life.

Next, the Blue Cluster – Health, Crisis Management, and Air Quality, which groups keywords such as healthcare (total quality management, air quality, public health and crisis management, telemedicine, waste management). This cluster highlights how artificial intelligence impacts systems such as health and environmental management.

Finally, the Yellow Cluster focuses on key terms such as decision-making, decision support systems, resource management and planning. This cluster highlights the fundamental role of artificial intelligence in providing tools that enable decision-makers to manage resources efficiently and optimise strategic planning, especially in areas linked to sustainable development.

The evolution of keywords highlights the central role of artificial intelligence as a versatile tool for addressing global challenges in sustainability, smart cities, health and strategic resource management, highlighting its cross-cutting impact on multiple areas of research and practice.

Most Relevant Sources

The bibliometric analysis identified the most relevant sources in research related to artificial intelligence, quality and sustainable development. These sources stand out not only for their volume of publications but also for their impact and contribution to advancing knowledge in these interrelated fields.

Affiliations are classified according to the number of articles published by each institution, and a distribution is observed that highlights the contribution of universities and research institutes from various countries.

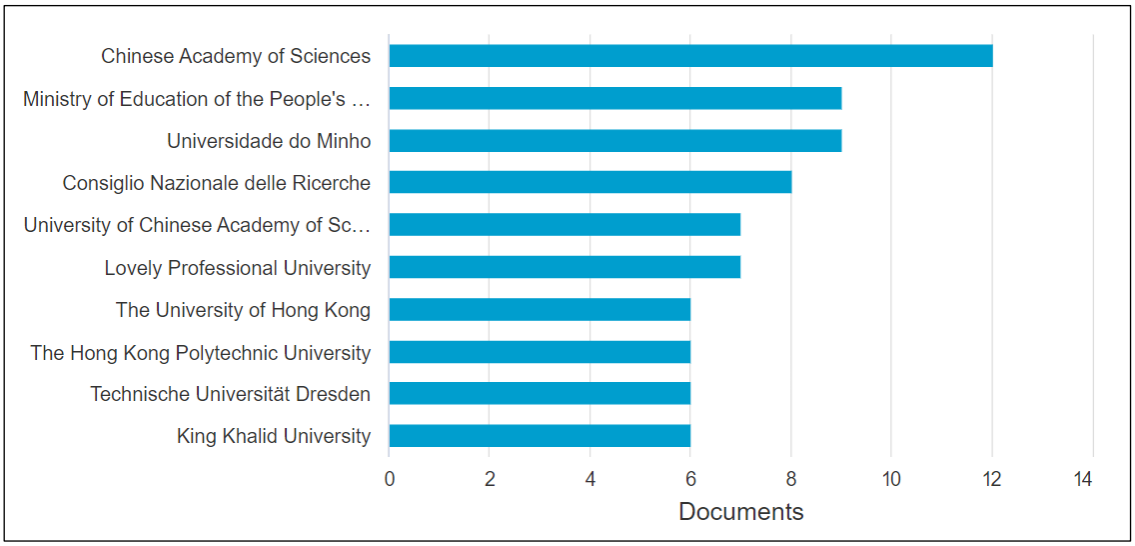

Figure 3 – Institutional Affiliation of Publications

Institutional Affiliation of Publications

As shown in Figure 3, the Chinese Academy of Sciences tops the list with 13 documents, indicating it is the most productive institution in this research area. This reflects its leadership in generating scientific knowledge on topics ranging

from advanced technologies to sustainability and quality. In second place is the Ministry of Education of the People's Republic of China, with 10 documents. The University of Chinese Academy of Sciences also appears on the list with 6 documents, highlighting China as a key country in producing research related to artificial intelligence, quality and sustainability.

On the other hand, there is great international diversity with the participation of several renowned institutions that also contribute significantly, such as the Universidade do Minho in Portugal, with 8 documents, and the Consiglio Nazionale delle Ricerche in Italy, with 7 documents, demonstrating that these European institutions also play a relevant role in advancing this area of research. In Europe, the Technische Universität Dresden (Germany) has a significant presence with 5 documents, highlighting the role of German universities in technological and sustainable research. And finally, King Khalid University (Saudi Arabia), with 5 documents, completes the list, indicating a growing interest in the Middle East region for this type of research.

The above panorama highlights the consolidation of artificial intelligence as a key tool for addressing global challenges, promoting sustainable practices and technological innovation in varied contexts.

Prominent Authors

Authors Abba, S.I., Grundmann, Jens, Schütze, Niels and Singh, Rajesh lead the publications with 4 documents each. This suggests that these researchers are key figures in scientific production related to the three study variables and have contributed significantly to the generation of knowledge in this field. Authors such as Akram, Shaik Vaseem, Alfaisal, Raghad, Artyukhov, Artem, Artyukhova, Nadiia, and Dutta, Ashutosh, stand out with 3 published documents each. While these authors have a slightly lower number of publications, they remain important players in the advancement of research on the study topics. The most cited author is Kusiak, A., with 914 citations, followed by Burton, M.J., with 700 citations, Palani, Y., Liong, S.-Y., Yakim, Y.

The analysis of authors highlights the existence of a core group of key researchers who lead scientific production at the intersection of artificial intelligence, quality and sustainability, reflecting a significant impact on the development of this field. Additionally, the presence of authors with a lower volume of publications, but with important contributions, suggests a diverse and expanding academic community.

Production by Countries

Figure 4 shows a global heatmap highlighting scientific output by country linked to artificial intelligence, quality, and sustainable development. The different shades of blue represent the number of publications, with darker colours indicating higher productivity. In this sense, China appears in the darkest blue, indicating that it is the country with the highest number of scientific publications in this area. Additionally, it was determined that much of the research conducted in China in this area is developed by national institutions without international collaboration.

India and the United States also have high scientific output. Both countries have numerous academic and research institutions that contribute significantly to the field of study and collaborate more actively in international research in this field.

On the other hand, several European nations (such as Germany, the United Kingdom and Italy) and Asian countries such as Japan and South Korea appear in a lighter shade of blue, indicating a moderate output of publications in this area. These countries are known for having intense research and development sectors, especially in emerging technologies such as AI and sustainability, and for their internal and international collaboration through research networks.

Brazil and South Africa also appear in lighter blue, highlighting their participation in scientific production, although on a smaller scale compared to major powers such as China or the United States.

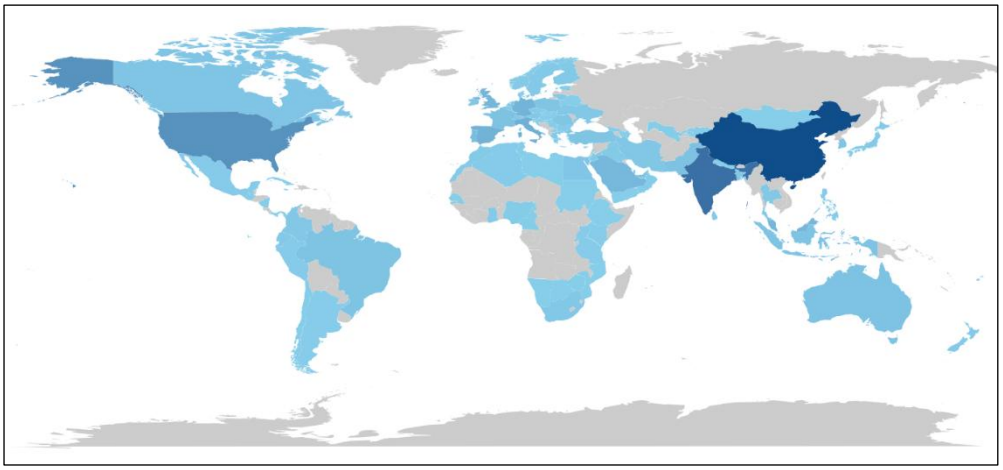

Figure 4 – Production by Countries

On the other hand, topics such as machine learning, artificial intelligence, sustainable development and climate change have experienced a notable increase in relevance since approximately 2017, reflecting a growing trend to the present day. On the other hand, terms such as decision support systems and water management have been consistently important over time, with a more recent focus on their application to critical areas such as resource management and sustainability. Overall, research has increasingly focused on the use of advanced technologies such as artificial intelligence and machine learning, applied to solving global challenges such as climate change and the efficient management of natural resources. These trending topics highlight the growing interest in using technology to address environmental and sustainability issues, underlining their importance in the current scientific agenda.

Background and Evolution of Artificial Intelligence

Artificial intelligence has evolved significantly, becoming a key tool for automating and optimising processes across various industries. From its early beginnings in solving computational problems, AI has advanced towards complex applications such as machine learning, processing large volumes of data, and

intelligent automation (D.-V. Nguyen et al., 2024). These developments have facilitated its integration into areas such as intelligent manufacturing, predicting market trends, and decision-making based on predictive analysis.

In the context of quality, AI has been fundamental in improving production processes by identifying faults, optimising resources, and driving continuous improvement (Groten and Gallego-García, 2021). Automation and the use of prescriptive systems allow for not only more precise quality control but also a significant reduction in production costs and times.

Artificial intelligence (AI) has significantly impacted sustainable development, improving water and agricultural management through intelligent irrigation systems and predictive analysis (Al-Busaidi and Al-Muharrami, 2021). Its integration into sectors such as renewable energy promotes greener and more efficient solutions. Research has focused on optimising water resources and minimising environmental impact, especially in areas with scarcity (Nathani, Pareyani and Ahirwar, 2024), using intelligent systems to improve resource planning and management.

Regarding quality, AI facilitates real-time monitoring and evaluation, enabling continuous improvement processes (Javaid et al., 2022). Additionally, machine learning is used in quality management to identify patterns in large volumes of data, optimise processes, and increase customer satisfaction (Aldoseri, Al-Khalifa, and Hamouda, 2023). This benefits various industries, including manufacturing, healthcare, and technology.

AI is a key ally in sustainable development, helping to reduce carbon footprints and manage resources efficiently. It contributes to predicting climate change, managing environmental risks, and promoting sustainable practices in areas such as urban planning and precision agriculture (Ziesche et al., 2023). It is also applied in assessing environmental impact and creating energy-efficient solutions (Sami et al., 2024).

Recent research has shown how AI can play a central role in the transition towards more sustainable economies, enabling governments and businesses to implement more effective measures to mitigate the effects of climate change (Vinuesa et al., 2020).

On the other hand, the intersection of artificial intelligence, quality, and sustainable development is driving new research and development opportunities, providing innovative solutions to complex problems (Mhlanga, 2022). As AI continues to evolve, its integration into quality improvement and sustainability processes will be crucial to addressing global challenges such as the climate crisis and resource optimisation (Liu et al., 2015).

The truth is that the convergence between artificial intelligence, quality, and sustainable development not only encourages technological innovation but also redefines how global challenges are addressed. This integrated approach allows for resource optimisation, improved decision-making, and the development of

more effective solutions in key sectors such as health, environmental management, agriculture, and smart cities.

Finally, it should be noted that the research reviewed in this bibliometric analysis highlights the growing importance of artificial intelligence as a tool to improve quality in production and to promote sustainable practices globally, being key in the future research agenda.

4 CONCLUSION

The bibliometric analysis conducted on the impact of artificial intelligence on quality and sustainable development reveals significant trends and scientific contributions at the intersection of these three variables. Based on an extensive review of the literature from 2000 to 2024, it is concluded that the field has experienced substantial growth, with an annual growth rate of 25%, reflecting the growing academic and practical interest in these topics.

Artificial intelligence (AI) has proven to be a transformative tool for optimising the quality of organisational processes, enabling improvements in production management, standards monitoring, and data-driven decision-making. This positive impact has been particularly evident in sectors such as manufacturing, healthcare, and technology industries, where AI is being utilised to enhance efficiency and reduce costs.

AI has played a crucial role in sustainable development by creating more efficient and eco-friendly solutions that reduce the carbon footprint, optimise the use of natural resources, and promote sustainable practices, particularly in areas such as precision agriculture and water resource management. Furthermore, international collaboration has been essential for advancing research, with countries such as China, the United States, and India being key contributors to scientific production, where co-authorship networks and inter-institutional collaborations have been instrumental in generating high-quality knowledge.

Overall, this bibliometric study confirms that the convergence of artificial intelligence, quality management, and sustainable development is driving innovation and research, suggesting a promising future for the implementation of these technologies across multiple sectors. As AI continues to evolve, its integration will be crucial in addressing global challenges in terms of sustainability and organisational efficiency.

Theoretical and Practical Implications

The findings of this bibliometric study offer both theoretical and practical benefits at the intersection of artificial intelligence (AI), quality management, and sustainable development.

From a theoretical perspective, the analysis provides a structured insight into the evolution of scientific production in this field, identifying key trends, influential

authors, and gaps in the literature that may guide future research. Moreover, it highlights the growing convergence between AI and organisational quality as a key factor for sustainability, offering a solid conceptual framework for further studies. In practical terms, the results demonstrate how the implementation of AI in quality management processes has optimised decision-making, enhanced operational efficiency, and reduced costs, particularly in sectors such as manufacturing and technology. Additionally, the study underscores AI's role in promoting sustainable practices by facilitating efficient resource management and waste reduction. In this regard, the findings can serve as a reference for policymakers, businesses, and international organisations seeking to drive technological innovation with a sustainable and quality-focused approach.

RESEARCH LIMITATION/IMPLICATION

Although there is a growing convergence between AI, quality, and sustainability, this study highlights notable gaps in research integration, particularly in underrepresented regions. Furthermore, limited attention has been given to emerging areas where AI could play a transformative role in advancing quality management and sustainable development. These findings underscore the need for broader geographic representation and a more comprehensive exploration of AI-driven innovations in future research.

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CONFLICTS OF INTEREST

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