

ARTIFICIAL INTELLIGENCE (AI) IN SUSTAINABLE TOURISM: BIBLIOMETRIC ANALYSIS

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ABSTRACT

Artificial Intelligence (AI) has gained attention in tourism, which requires its sustainability. Our study focuses on a bibliometric analysis of AI in sustainable tourism using 174 manuscripts from 2000 to 2022. One of the main findings is that 'intelligence' appears frequently, followed by related terms such as work, performance, resources, sustainability, impact, optimization and management. There is no previous evidence on AI in the context of sustainable tourism to explain how public managers or politicians design public policies to create and improve resource efficiency.

Keywords: Artificial intelligence (AI); sustainable tourism; bibliometric analysis; VOSviewer; Artificial intelligence's impacts

Inteligencia artificial (IA) en turismo sostenible: análisis bibliométrico

RESUMEN

La Inteligencia Artificial (IA) ha ganado atención en el turismo, que requiere su sostenibilidad. Nuestro estudio se centra en un análisis bibliométrico de la IA en el turismo sosteni-

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ble utilizando 174 manuscritos de 2000 a 2022. Una de las principales conclusiones es que “inteligencia” aparece con frecuencia, seguida de términos relacionados como trabajo, rendimiento, recursos, sostenibilidad, impacto, optimización y gestión. No existen pruebas previas sobre la IA en el contexto del turismo sostenible que expliquen cómo los gestores públicos o los políticos diseñan políticas públicas para crear y mejorar la eficiencia de los recursos.

Palabras clave: Inteligencia artificial (IA); Turismo sostenible; Análisis bibliométrico; VOSviewer; Impactos de la inteligencia artificial.

1. INTRODUCTION

Artificial Intelligence (AI) plays a crucial role in tourism, developing technical systems like Blockchain and the Internet of Things (IoT) to support businesses online, enhancing the business-customer relationship. Integrating advanced technologies like Augmented Reality (AR) and Virtual Reality (VR) offers a comprehensive solution for sustainable tourism. AI optimizes resource allocation, personalizes visitor experiences, and formulates data-driven sustainability strategies.

The definition of AI has evolved from having some form of intelligence to having the ability to act autonomously on large amounts of data, to using past experience and memory to make better decisions (Bulchand-Gidumal, 2020). AI is the science and engineering that aims to create intelligent hardware and software (McCarthy, 2007) designed to replicate human thought processes and reasoning performance (Russell and Norving, 1995). Furthermore, AI refers to a set of technologies that enable electronic devices to exhibit human intelligence, such as sensing, perceiving, interpreting, or learning (Bowen and Morosan, 2018). Marr's (1977) characterization of AI in two parts (type 1 - physical and type 2 - algorithms) and the definition of what constitutes a result of his work at the Artificial Intelligence Laboratory of the Massachusetts Institute of Technology is probably acceptable to most scientists, “is the study of complex information processing problems, often rooted in some aspects of biological information processing”. AI plays a crucial and central role in the tourism industry (Koo *et al.*, 2015). In addition, prior research (Hunter *et al.*, 2015) has suggested that new ways – smart tourism – of doing business, new patterns of behavior, and new problems concerning tourism destination image management and marketing are emerging due to the ubiquitous presence and influence of the Internet and mobile devices, as well as e-commerce and virtual reality (VR); tourist experience and augmented reality (AR); and destination image formation. Artificial Intelligence emerges as a pivotal facilitator in enhancing tourism operations and decision-making processes (Rane *et al.*, 2023). Moreover, Rane *et al.*, 2023 highlighted the potential of a technology-driven approach to redefine tourism practices to ensure not only environmental but also social and economic sustainability in the long term.

Tourism is one of the world's fastest-growing industries, a significant source of foreign exchange and employment, and is linked to the social, economic, and environmental well-being of many countries, particularly developing countries. According to the World

Tourism Organization, a specialized agency of the United Nations (UNWTO, 2023), “tourism is a social, cultural and economic phenomenon that involves the movement of people to countries or places outside their usual environment for personal, professional or business reasons”. Tourism is also seen as a key element of economic growth, reducing social inequalities and poverty by promoting employment, so it is not surprising that it is used as the main strategy for the development of a given region (Romagosa *et al.*, 2020).

The introduction of the sustainability approach in tourism provides a comprehensive, pragmatic, and realistic view of the development and management of tourism activities. For its part, sustainable tourism is defined by the United Nations Environment Program and the United Nations World Tourism Organization as “tourism that takes full account of its current and future economic, social and environmental impacts, addressing the needs of visitors, the industry, the environment, and host communities (United Nations and Department of Economic and Social Affairs Sustainable Development, 2023). In recent years, there has been an increased interest in sustainable tourism studies, as evidenced by a bibliometric analysis, for example, Valsaraj *et al.* (2024) reviewed 32 papers published in the Indian context on sustainable development tourism. Indeed, other studies such as the use of digital technology in tourism such as Dziurakh *et al.* (2024), who research the study of innovative technologies with practical applications in the tourism industry; Asif and Fazel (2024) highlighted that digital technology in tourism shows a significant growth in annual scientific production, peaking at 100 articles in 2023.

Since social interaction is a key resource in the tourism sector, many of these technological advances seem to contradict the very *raison d’être* of the sector. One of these advances, artificial intelligence, has tried to fill this gap through science. The tourism sector is undergoing a process of automation in an attempt to improve its effectiveness in service delivery and efficiency. The adoption of artificial intelligence should be an opportunity to develop robotic applications that can help in travel and tourism by providing security and comfort services (concierge, check-in or check-out of hotel rooms, house-keeping, food, and other service tasks) despite the concerns of the past about job losses or confidentiality of data privacy. Moreover, Rane *et al.*, 2023 highlighted the potential of a technology-driven approach to redefine tourism practices to ensure not only environmental but also social and economic sustainability in the long term. Regarding the relationship between how to support artificial intelligence in sustainability and how to be efficient AI in tourism?. For instance, AI can help to support data management, project design in all areas of business management, stakeholder relations, public and private collaboration and people’s decision-making processes.

AI supports data management, project design in all areas of business management, stakeholder relations, and public and private collaboration, the decision-making process performed by people.

The purpose of this paper is to study the production of Artificial Intelligence (AI) in sustainable tourism using bibliometric analysis. The aim of this bibliometric study is to analyze articles on the impact of artificial intelligence in the sustainable tourism sector. For this purpose, the documents of the Web of Science (WOS) database in the field of economics and social sciences, the evolution of the field of study, the main sources, the authors, the most cited papers, and the main impacts are analyzed. This analysis highlights

the importance of a business model where AI is used to improve the competitive position of the company and points out possible future research trends where the impact of Artificial Intelligence on the sustainability of the tourism sector is studied.

In the service sector, there have been attempts to develop four specific capabilities in these machines and programs that could add value to the tourism experience: mechanical, analytical, intuitive, and empathetic (Huang and Rust, 2018). This last skill is proving to be more difficult to develop, and currently artificial intelligence has been implemented in the tourism sector to automate processes (intelligent automation) that have replaced some operations that traditionally required a personal touch, such as check-ins, virtual assistants, chatbots, among others (Tussyadiah, 2020).

This artificial intelligence applied to sustainable tourism can help develop more powerful systems that can store and process massive amounts of data, analyze large volumes of data, and learn from their own and other people's experiences in fulfilling customer orders, creating a personalized product much faster than traditional search technologies. In effect, AI is helping to create a more personalized and memorable experience for lodging guests, while also reducing labor costs for companies. (Bulchand-Gidumal, 2020; Kazak *et al.*, 2020; Li *et al.*, 2019).

Some researchers explain that the use of robots in tourism can increase the efficiency of work, and the quality of services, and reduce financial costs (Ivanov and Webster, 2019). Other researchers argue that robots can help people move from low-skilled to high-skilled jobs. Technology-enabled tourism experiences increasingly facilitate travelers to co-create value at all stages of travel (Neuhofer *et al.*, 2014). However, many challenges to the adoption of robotics that could result in large numbers of people losing their jobs (Boyd and Holton, 2018). This innovation may also include a lack of popularity in consumer interactions, ethical dilemmas, privacy issues, inefficient and failing systems, digital exclusion, loss of knowledge and information, threats to language and culture, elimination of human touch, and threats to human survival (Townsend, 2017).

Nowadays the adoption of robotics, autonomous vehicles, drones, artificial intelligence, and human-robot interactions have increased to help (hotels, airports, restaurants, hospitals, transportation, recreation, and communities in general) in many different ways to reduce human contact after the COVID-19 pandemic, being used to manage this disease. In particular, China in robotics has advanced in its applications during these social distancing practices. However, research on robots has been extremely limited (Ivanov *et al.*, 2017). The adoption of social robots is not optimistic, mainly due to the tourism industry's desire to maintain high-touch amenities (Zeng *et al.*, 2020). Similarly, the application of artificial intelligence in travel, tourism, and hospitality companies has received some, but not enough, attention from scholars (Borràs *et al.*, 2014). Covid-19 has provided an opportunity for creative innovations in which robotics and artificial intelligence can improve the quality and sustainability of the travel and tourism experience (information system to monitor natural resources, education on acceptable behavior, navigation system to prevent overcrowding and overtourism).

As a result, based on the relevance of the application of artificial intelligence in the last decades' literature analyzed, the following research questions are posed: What are the main issues addressed in artificial intelligence and sustainable tourism? Is artificial intelligence

a valid tool for creating value in the sustainable tourism sector? How has the topic evolved over the last decades? Furthermore, the study will allow us to observe whether, during the period of the COVID-19 crisis, the literature has increased its interest in the use of artificial intelligence in a sector that is highly sensitive to the pandemic. Also, the study will indicate whether AI in tourism is a current research topic or in its early stages, who is developing these studies, and the gaps and possible research trends. In light of the above, this bibliometric study aims to ensure that the analysis will guide future researchers and provide guidance for the management of artificial intelligence in tourism enterprises. With the growing importance of AI among IT professionals, researchers and, tourism, a large body of research on AI applications in tourism, especially in sustainability, has emerged in recent years. A sector that has challenges and opportunities with the SDGs. Therefore, it is important to review the existing relevant research to understand the intellectual framework and knowledge flow on AI applied to sustainable tourism, to review the thematic evolution, and to propose avenues for future research. Therefore, this bibliometric analysis has the following objectives: (i) to quantify the volume of production of AI-related articles in sustainable tourism research and to describe the main scientific journals, authors, countries and, institutions publishing in this field, as well as the most influential articles and author networks; and (ii) to identify and analyze the most relevant topics and develop a thematic map of research on AI. This study contributes to the literature on sustainable tourism by identifying metrics, topics, and trends that reflect the state of knowledge of research on AI and by stimulating further research.

The remainder of this paper is organized as follows: after reviewing the use, impact and drivers of AI applied to tourism, the study methodology is explained; the bibliometric analysis is developed and the main findings are analyzed. Finally, the main conclusions are presented.

2. LITERATURE

The review of literature on artificial intelligence in tourism has focused on two areas: the development of artificial intelligence programs and their impact - especially on consumers. In this sense, we develop a first subsection on the use of artificial intelligence in the sector, and a second on its impact, and third section on the factors that influence its impact.

2.1. Uses of Artificial intelligence

Artificial intelligence has been used in various fields such as robotics, computer science, finance, health, autonomous transportation systems, video games, and telecommunications. However, as Zeng *et al.*, (2020) highlight, although there are ongoing developments of high-tech services. Innovation technologies have not yet been considered in new areas and enhance the quality and sustainability of travel and tourism experiences. For example, the adoption of robotics and AI in tourism to better monitor and protect natural and cultural resources. Information systems to detect unusual behavior towards protected areas or tourist areas, to educate tourists when they visit any destination, and to detect,

and prevent natural disasters, a priority need related to the fight against climate change. Given that the implementation of AI in the tourism sector is recent, we can expect that research on the impact of AI on sustainable tourism is in its early stages, so we formulate the following hypothesis:

H1. AI in sustainable tourism is a current research topic.

In the field of travel, AI has been used to analyze information (text and images) to study consumers' satisfaction with the service, their behavior, or the evaluation of their experience based on data mining. Wang *et al.*, 2020 show that the AI photo identification framework is of great benefit for understanding projected destination images and enhancing tourism experiences. In fact, due to the importance of tourism destination image (TDI) in destination marketing (Deng and Li, 2018), feeling a destination through the right photos (with a machine learning model for DMO photos). In addition, the growing demand in the tourism sector in recent years has led to the creation of tourism demand forecasting algorithms to improve economic planning (Zeng *et al.*, 2021). The increasing use of AI in the sector has been able to increase research interest in recent years on AI in sustainable tourism. The above makes us formulate the following research hypothesis:

H2. Research on AI in sustainable tourism has increased in the last decade.

COVID-19 drove the adoption of robotics; robotics, artificial intelligence, and human-robot interactions have been used to maintain social distance to manage the disease of COVID-19 in hospitals, airports, transportation systems, recreational and scenic areas, hotels, restaurants, and communities in general (Zeng *et al.*, 2021). Examples of AI are transforming a range of industries, including robotics, healthcare, tourism, transportation, finance, education, and others. AI devices such as smart devices, self-service devices, chatbots, and service robots have been widely used to provide frontline services (Chi *et al.*, 2020). The tourism sector involves close contact with the consumer. The use of AI during pandemics has allowed us to maintain and manage service delivery more safely. The above leads us to believe that AI research in the tourism sector after the COVID-19 crisis has increased. Moreover, several authors have emphasized the key role of sustainability resources, tourism development, and maintaining essential ecological processes, such as ecotourism. For this reason, the hotel industry is an important consumer of energy that needs efficient energy management methods to guarantee its performance and sustainability. Therefore, another application of artificial intelligence in the tourism sector has been used for the efficient management of resources. As an example of this, AI has been used for the responsible use of energy consumption (Casteleiro-Roca *et al.*, 2019). The energy crisis suffered after COVID-19 may also have encouraged research on AI as a tool to improve sustainability and efficiency in the tourism sector, so we formulate the following hypothesis:

H3. AI research in sustainable tourism after the COVID-19 period has increased.

2.2. Impact of (AI) in the tourism

The literature on AI in the tourism sector focuses on the study of the impact of its application mainly on consumers, focusing on the positive side, but there is also a dark

side. Although the adoption of these technologies is still in its early stages, studies in other sectors suggest that they could have a significant impact on tourism operations (Alonso, 2019). The studies revolve around the creation of value in the consumer, analyzing the consumer's perception of value, trust in technologies (Park, 2020), and/or the acceptance of artificial intelligence by consumers and users in the tourism sector, influenced by social influence, hedonic motivation, anthropomorphism, performance (Chi *et al.*, 2022).

One of the arguments for the acceptance of this technology is its ease of use. Artificial intelligence is based on mimicking human behavior, which makes it easier for the user to use and interact with this technology (Lv *et al.*, 2021). In addition, technology-enabled tourism experiences are increasingly supporting travelers to co-create value at all stages of travel (Buhalis, 2020). However, another part of the literature points to the value deficit they create in the consumer because although artificial intelligence services can provide an efficient service, they undermine the tourist experience, which is largely determined by social interaction. For example, how the metaverse will change the sustainable travel industry (Go and Kang, 2023). Considering these recent studies and the importance of value creation in consumer perception within the tourism sector, we can expect that research has focused on the impact of AI on the consumer, formulating the following hypotheses:

H4. The topics used in research on AI in sustainable tourism revolve around consumer satisfaction and perceptions.

Thus, AI is located between the employees of the tourism service and the guests or consumers. It may also include privacy issues, inefficient and failing systems, and the elimination of the human touch (Townsend, 2017), and no player will escape its impact (Buhalis, 2020). Regardless of the type of artificial intelligence you use in your operational practice (humanoid robots, drones). Inevitably, intelligent environments will transform industry structures, processes and practices, with disruptive effects on service innovation, strategy, management, marketing and competitiveness of all stakeholders (Buhalis, 2020). Based on the previous literature and given that the tourism sector is a sector with a high dependence on labor, we can expect to study the impact of AI on employees linked to sustainable tourism, so we formulate the following research hypothesis:

H5. The topics used in research on AI in sustainable tourism revolve around the impact on employees and employee well-being.

2.3. Factors influencing artificial intelligence

Some factors that have contributed to the growth of artificial intelligence at the meso or individual level, certain factors are identified that influence the creation of value offered by artificial intelligence in the tourism sector. The sympathy of the artificial intelligence assistant mitigates the negative effects of errors or failures of the service provided. Being the most tolerant consumer to failures (Lv *et al.*, 2021). At the micro or business level, the tourist service offered determines the perception of the value of artificial intelligence. Thus, sectors based on obtaining experiences rather than results, the search for social relationships, or those services in which human resources generate

more expectations in terms of better performance influence the consumer's perception of value. Indeed, social influence is a stronger determinant in hospitality services than in airline services. Tourists have higher performance expectations from AI devices used to provide airline services compared to hospitality services (Chi *et al.*, 2022). Advances in innovation - service automation and robotics technologies - have entered the lodging segment of the hospitality industry, impacting various areas of hotel operations (serving customers, supporting employee tasks), such as self-service kiosks and mobile devices to complete check-in and check-out services, improving convenience and service speed. Mobile technology to integrate mobile service ordering into a seamless hotel guest experience of communication in real-time, placing the request right at the customer's fingertips. In summary, AI is changing the sustainable performance of tourism companies, affecting social performance (e.g., via human resources, and consumer satisfaction) and environmental and financial performance (e.g., via process optimization). Based on the above, we can formulate the following research hypothesis:

H6. The research shows that AI creates social, economic and financial value in sustainable tourism.

One consideration that should be taken is that not all service processes need to be automated by robots, although it is necessary to examine other factors such as the customer experience, economic efficiency, company's competitiveness, among others that will determine whether to robotize and automate the service delivery process. According to the International Federation of Robotics (IFR, 2021), the use of industrial robots continues to grow. For example, the year 2020 is the third most successful year for the robotics industry, with global robot installations to 383,545 units sales, so far, after 2019 global robot installations of 373,240 units sales.

This follows a year of growth a peak value of 2.76% (IFR, 2021). Asia is the world's largest industrial robot market, then, 76% of global robot installations in the five major markets for industrial robots are China, Japan, the United States, the Republic of Korea and Germany countries.

Similarly, Kelly *et al.*, (2023) show that cultural factors are also an important consideration when comparing acceptance studies across different demographics. TAM is the most commonly used model adopted to measure acceptance and has been found to be the most successful in measuring behavioral intentions and progress in deep learning (Bowen and Morosan, 2018; Deng and Li, 2018).

Given that there are cultural differences and the region or country influences the development and implementation of AI, we can formulate the following research hypothesis:

H7. There are differences in interest in AI research in the tourism sector depending on academic institutions and countries.

3. METHODS AND MATERIALS

The main purpose of this study is to provide a comprehensive bibliometric analysis of the existing literature on artificial intelligence in sustainable tourism. For this purpose, and in line with recent research trends such as metaverse in tourism (Go and Kang, 2023), with rapidly distributed technologies of the IoT (Internet of Things) and the use of smart

wearable devices (Park, 2020), trends and patterns in sustainable tourism (Valsaraj *et al.*, 2024), the use of digital technology in tourism (Asif and Fazel, 2024; Dziurakh *et al.*, 2024), our study of the bibliometric analysis of AI in sustainable tourism is based on the research framework shown in Figure 1.

3.1. Database and search protocol

Bibliometric analysis has been used for this research work. The methodology consists of identifying, organizing, and analyzing the main components related to a specific research area (Cobo *et al.*, 2011). Through the use of statistical, mathematical, and mapping tools, a total of 174 articles on the terms intelligence, sustainability, and tourism have been analyzed to identify the existing correlations.

The Web of Science database was chosen because it allows access to scientific resources published by different sources such as Elsevier, Springer, Emerald, or Wiley since it has a high number of papers, authors, and journals while meeting the peer-review requirements for scientific quality. The search for this research was carried out in June 2022, while the statistical analysis has focused on the last 22 years, that is from the study period 2000-2022.

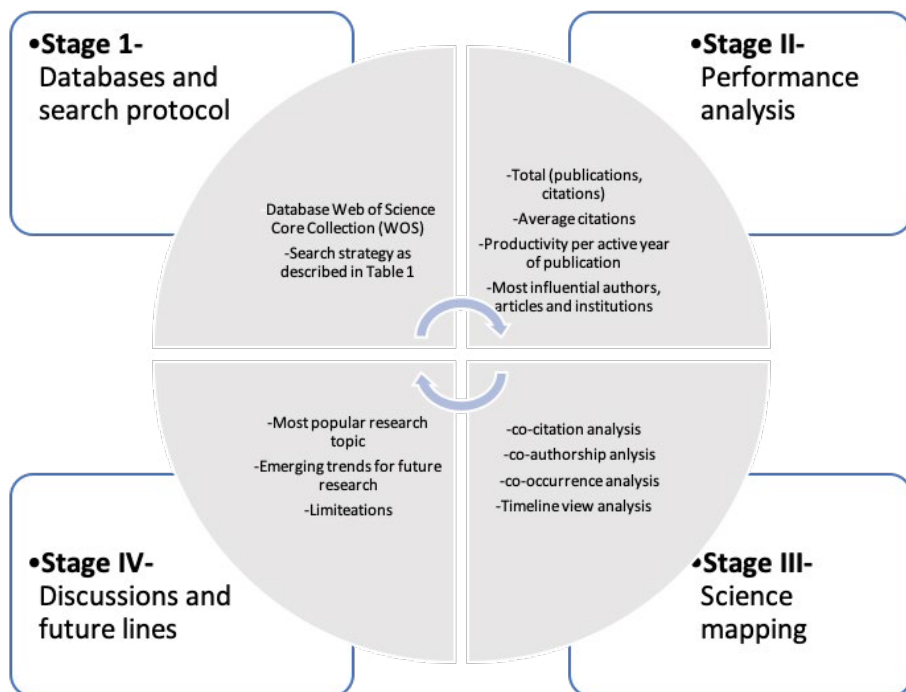
In this sense, the year of publication, the journal, the subject area, the author and co-author, the institution, the country, and the keywords are included in the analysis through the VOSviewer tool (Asif and Fazel, 2024; Dziurakh *et al.*, 2024; Van Eck and Waltman, 2010).

The sequence applied to obtain the data to be studied, first: selection of search criteria intelligence (all Fields) AND sustainability (all Fields) AND tourism (all Fields), second selection of database (Web of Science), time frame (2000-2022) type of documents articles, third documents search 174, four: export final database, and five mapping with VOSviewer, analysis and discussion. This software generates a graphical representation of bibliometric maps as distance-based maps and graph-based maps allowing grouping and processing of words extracted from scientific literature (Van Eck and Waltman, 2010). To provide a comprehensive map of the knowledge structure in the field of artificial intelligence in sustainable tourism.

We have adopted the Web of Science database search that followed one of the best-known systematic review protocols. Previous studies of bibliometric analysis have used this methodology for example, Asif and Fazel (2024) explore the transformative trends in the intersection of digital technology and tourism with 575 articles, and Dziurakh *et al.*, (2024) combined innovative technologies with smart tourism with 103 publications), Amar *et al.*, (2023) analyses the relationship between tourism development and entrepreneurship, and the importance of political institutions in promoting economic growth, among others.

Data extraction for bibliometric analysis was performed using the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) protocol, which incorporates new guidelines in the methods for identifying, selecting, assessing, and synthesizing studies as recently revised by Page *et al.*, (2021).

Figure 1
RESEARCH FRAMEWORK OF THE METHODOLOGY



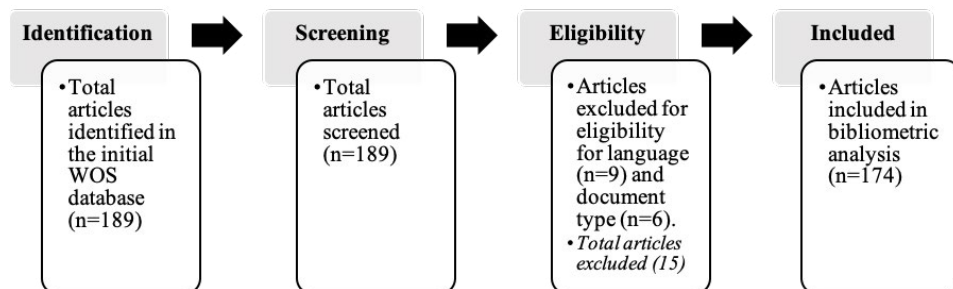
Source: Created by the author.

The PRISMA flowchart used in this research is shown in Figure 2. The methodology consists of identifying, organizing, and analyzing the main components regarding of a specific research field (Cobo *et al.*, 2011). Using statistical, mathematical, and mapping tools, a total of 174 articles on the terms Intelligence, sustainability, and tourism have been analyzed to identify the existing correlations.

The Web of Science Core Collection (WOS) database has been selected, this database allows access to scientific resources published from different sources such as Elsevier, Springer, Emerald, or Wiley, as it has a high number of papers, authors, and journals while meeting the peer-review requirement for scientific quality and is a reliable source for indexing highly ranked journals (Caputo *et al.*, 2021).

The search began on 3 July 2022 and ended on 2 September 2022, while the statistical analysis has focused on the last 22 years, that is from the study period 2000-2022. In this sense, the year of publication, the journal, the subject area, the author and co-author, the institution, the country, and the keywords are included in the analysis through the VOSviewer tool (Van Eck and Waltman, 2010).

Figure 2
PRISMA FLOWCHART FOR SYSTEMATIC REVIEW



Source: Created by the author and adapted from Page *et al.* (2021)

The sequence applied to obtain the data to be studied, first: selection of search criteria Intelligence (All Fields) AND sustainability (All Fields) AND tourism (All Fields), second selection of database (Web of Science), Time frame (2000-2022) Type of documents articles, third documents search 189 excluded for eligibility and language 9 and document type 6, four: export final database, and five Mapping with VOSviewer, analysis and discussion.

This software generates a graphical representation of bibliometric maps as distance-based maps and graph-based maps allowing grouping and processing of words extracted from scientific literature (Van Eck and Waltman, 2010). Finally, in total 174 research articles were retrieved from the Web of Science data, for further analysis using a Bibliometric approach and software VOSviewer.

Table 1
CRITERIA FOR SELECTING INFORMATION

Category	Criteria	No. of refined articles
Search string used in the search refinement	TOPIC: ('Intelligence') AND TOPIC ('Sustainability') AND TOPIC ('Tourism')	189
Access	Including both Open Access and others	
Period (years)	2002 including only articles until 2022.	
Subject area	The search was limited to the following WOS categories: Computer Science, Artificial intelligence, Computer Science cybernetics, Green Sustainable Science Technology, Economics, and Management. WOS categories such as engineering, computer, construction, biology, chemistry, medical, and others were excluded.	

Category	Criteria	No. of refined articles
Document type	The search was limited to document type articles. Therefore, documents such as editorial material, proceedings papers, books, book reviews, and meeting abstracts were excluded.	(6)
Language	All articles published in other language than English were excluded	(9)
The Final number of articles remaining after manual refinement		174

Source: Created by the author.

4. RESULTS AND DISCUSSION

Following the methodology described in the previous section, this section presents the results of a comprehensive bibliometric analysis of scientific publications related to artificial intelligence in sustainable tourism, in terms of articles, authors, journals, and identification of conceptual research themes in this field.

4.1. Performance analysis

As presented in Table 1, this study is based on 174 articles on artificial intelligence in sustainable tourism related to computer science and green sustainable science technology disciplines published in journals. The presentation of several bibliometric indicators provides the following statistical perspectives: i) the number of publications related to artificial intelligence in sustainable tourism and the number of citations, ii) co-authorship analysis, iii) the most active institutions contributing to publications related to artificial intelligence in sustainable tourism, iv) countries contributing to publications related to sustainable business performance, v) co-occurrence analysis of keywords, vi) citation analysis.

Previous research has also used these network maps to identify key themes, influential authors, and prominent journals based on bibliographic data (Amar *et al.*, 2023; Asif and Fazel, 2024; Dziurakh *et al.*, 2024; Valsaraj *et al.*, 2024; Van Eck and Waltman, 2010).

4.1.1. Evolution over time of the number of publications and citations related to artificial intelligence in sustainable tourism

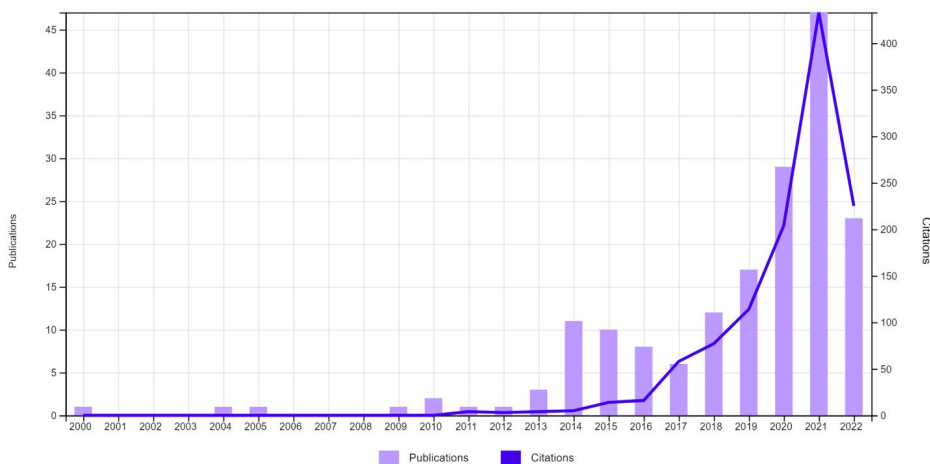
The dataset consists of 174 publications from 2000 to 2022 and the evolution of the number of publications over time is shown in Figure 3. Despite the long period (22 years) in which these articles were published, the academic interest in this field of research

area has started to increase significantly in the last five years (2017-2021). This trend in the number of publications continues to increase, while for 2021, the highest number of publications can be seen. Regarding 2022 this year was not fully included in the sample (until June 2022).

This finding strongly supports that this topic research related to artificial intelligence in sustainable tourism will be of increasing interest to researchers, especially in the context of really mean social transformation such as a modern approach in the carrying out of new business models in tourism service delivery with smart wearable devices.

The same trend is observed in the increasing evolution of the number of citations is observed as shown Figure 3. Furthermore, it can be noted that the highest number of citations so far was registered in 2021 (citations 433).

Figure 3
EVOLUTION OVER TIME OF THE NUMBER OF PUBLICATIONS AND CITATIONS RELATED TO ARTIFICIAL INTELLIGENCE IN SUSTAINABLE TOURISM



Source: Created by the author.

Table 2 shows significant information on the total number of publications, citations, authors, countries, average citations (TC/A), and journals that contributed to this research field related to Artificial Intelligence in Sustainable Tourism. An interesting phenomenon may be observed when analyzing the data presented in Table 2. The highest number of articles (99), authors (383), countries (138), and citations (862) were registered in the years 2020 to 2022.

The graph shows that AI in sustainable tourism is a recent research area, research has been developed in the last years and follows an increasing trend, accepting hypothesis 1. As we can observe research has started to grow exponentially in the last decade, accepting

hypothesis 2. Moreover, after COVID-19 the slope of the curve reflecting the number of publications increases, accepting hypothesis 3.

Table 2
EVOLUTION OVER TIME OF THE NUMBER OF ARTICLES, AUTHORS, COUNTRIES, CITATIONS, TC/A AND JOURNALS RELATED TO ARTIFICIAL INTELLIGENCE IN SUSTAINABLE TOURISM

Year	Articles	Authors	Countries	Citations	TC/A	Journals
2000-2001	1	2	1	0	0	1
2002-2003	0	0	0	0	0	0
2004-2005	2	5	1	0	0	2
2006-2007	0	0	0	0	0	0
2008-2009	1	2	1	0	0	1
2010-2011	3	7	3	4	1,33	3
2012-2013	4	17	6	7	1,75	4
2014-2015	21	56	6	19	0,90	21
2016-2017	14	38	16	74	5,29	14
2018-2019	29	90	38	191	6,59	29
2020-2022	99	383	138	862	8,71	99

Source: Own elaboration. (TC/A): An average of citations per article.

4.2. Science mapping analysis

The main purpose of the science mapping analysis is to summarize the bibliometric structure and intellectual structure of the selected research field (Asif and Fazel, 2024; Caputo *et al.*, 2021; Dziurakh *et al.*, 2024; Valsaraj *et al.*, 2024; Van Eck and Waltman, 2010), by using certain techniques for science mapping (such as co-citation analysis, co-occurrence analysis, bibliographic coupling, co-authorship analysis) combined with enrichment bibliometric techniques (such as networks and clustering visualization).

4.2.1. Co-authorship analysis

Co-authorship analysis examines the intellectual collaboration between researchers and research institutions based on the number of co-authored publications. This type of analysis is often used to understand and assess patterns of scientific collaboration in particular research fields. A total of 7 co-authors were identified for our 174 articles

Table 3
TOP 7 AUTHORS IN TERMS OF BIBLIOGRAPHIC COUPLING LINK STRENGTH

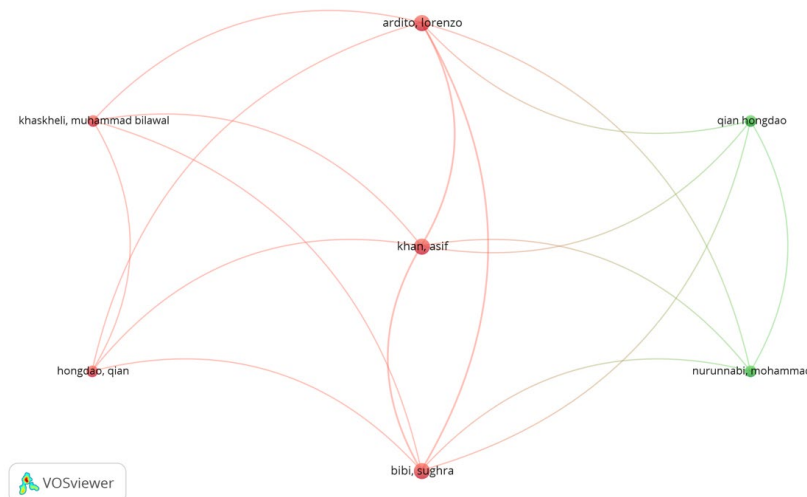
Author	Documents	Citations	Total link strength	Average Pub Year	Cluster
Ardito Lorenzo	2	22	8	2019	1
Khan Asif	2	22	8	2019	1
Bibi Sughra	2	22	8	2019	1
Khaskheli M.	1	10	4	2019	1
Hongdao Qian	1	10	4	2019	1
Quian Hongdao	1	12	4	2019	2
Nurunnabi M.	1	12	4	2019	2

Source: Created by the author based on the VOSviewer analysis.

Note: In this case, the total link strength represents the total strength of the co-authorship links between a given author and other authors.

Regarding the restriction of a minimum number of documents and minimum number of citations of an author one, some of the 63 items in the network are not connected to each other. The largest set of connected items consists of only 7 items (2 clusters), links 17, total link strength 20. Cluster 1 in red (Ardito Lorenzo, Bibi Sughra, Hongdao Qian, Khan Asif, Khaskeheli Muhammad) and cluster 2 in green (Nurunnabi Mohammad and Quian Hongdao), see Figure 4.

Figure 4
CO-AUTHORSHIP AND AUTHOR WITH ASSOCIATION STRENGTH



Note: network visualizations based on document weights.

4.2.2. *Most active institutions contributed to publications related to Artificial Intelligence in sustainable tourism*

Table 4 shows the top 8 most active institutions that contributed to this research field related to artificial intelligence in sustainable tourism. Regarding the restriction of a minimum number of documents and a minimum number of citations of an author zero, for each of the 58 organizations, the total strength of the co-authorship links with other organizations are calculated. The organizations with the greatest total link strength are selected 8 organizations with (2 clusters), links 16, total link strength 19.

An interesting phenomenon can be observed when analyzing the data presented in Table 4, when the first three institutions (Zhenjiang University, Hazara University, and University Campus Biomed Roma) are ranked first, second, and third, since the number of publications is also in the same position as the number of citations. The following positions, Prince Sultan University and the University of Oxford with (12 publications) recorded a higher number of citations for their publications.

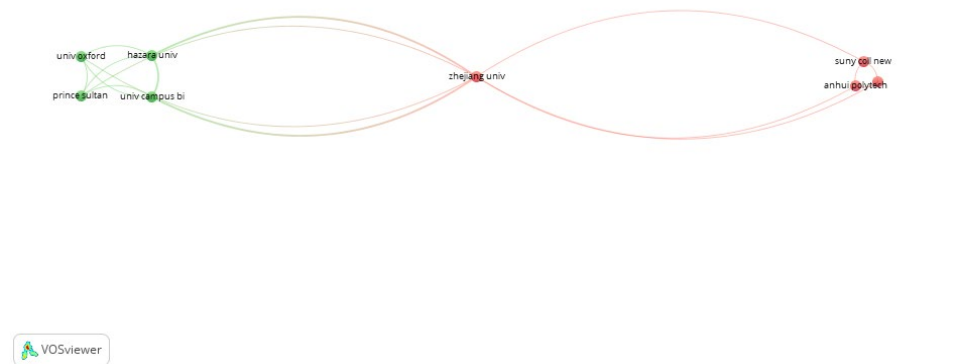
Table 4
CO-AUTHORSHIP AND ORGANIZATION WITH ASSOCIATION STRENGTH

Organization	Documents	Citations	Total link strength	Average Pub Year	Cluster
Anhui Polytech University	1	0	3	2022	1
Suny Coll New Paltz	1	0	3	2022	1
University Sci and Tech. China	1	0	3	2022	1
Zhejiang University	3	22	9	2020	1
Hazara University	2	22	9	2019	2
Prince Sultan University	1	12	4	2019	2
University Campus Biomed R.	2	22	6	2019	2
Univesity Oxford	1	12	4	2019	2

The authors with the highest number of citations correspond to Ardito Lorenzo, Bibi Sughra, and Khan Asif with 22 citations each grouped in Cluster 1.

Cluster 1 in red with 4 items (Anhui Polytech University, Suny Coll New Paltz, University Sci and Technology China, Zhejiang University) and *Cluster 2* in green with 4 items (Hazara University, Prince Sultan University, University Campus Biomed Roma, University Oxford), see Figure 5.

Figure 5
CO-AUTHORSHIP AND ORGANIZATION WITH ASSOCIATION STRENGTH



Note: network visualizations based on document weights.

4.2.3. Countries contributed to the publications related to sustainable business performance

Table 5 lists the top 7 most productive countries in this research field classified according to the number of articles. The most influential countries are the People’s Republic of China (9 articles cited 61 times), the USA (7 articles cited 56 times), and Turkey (4 articles cited 46 times).

Table 5
CO-AUTHORSHIP AND COUNTRIES WITH ASSOCIATION STRENGTH

Country	Documents	Citations	Total link strength	Average Pub Year	Cluster
People’s Republic of China	9	61	9	2020	2
USA	7	56	8	2020	1
Turkey	4	46	5	2019	1
Italy	3	44	5	2018	2
Pakistan	2	22	4	2019	2
South Korea	2	24	3	2019	1
Singapore	2	25	2	2018	1

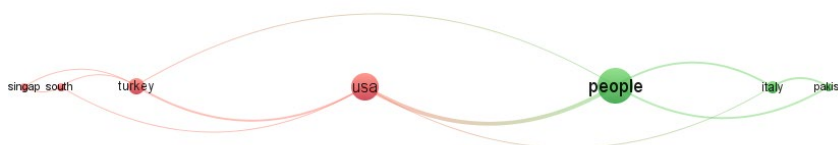
Source: Created by the author..

The analysis co-authorship of countries has the restriction of a minimum number of document 2 and a minimum number of citations of country 4. Regarding the results of the 22 countries, 7 meet the thresholds. Then, the largest set of connected items consists of 7 items with 2 clusters, links 11 with a total link strength 18. *Cluster 1* in red with 4 items (USA, Turkey, South Korea, Singapore) and *Cluster 2* in green with 3 items (People's Republic of China, Italy, Pakistan), see Figure 6.

Overall, a positive and steady growth trend in countries' interest in the utilization of AI in sustainable tourism. The most cited publications underscore the importance of the theme in the period, researchers are from China (61 cited). The most cited publications underline the importance of the topic and the majority of researchers are from China (61 cited). This trend can be explained by the most cited publications on the topic too (Table 8).

From the analysis of Tables 3, 4 and 5 we can see that the research on AI in sustainable tourism varies between countries, institutions and researchers, which leads us to accept Hypothesis 7.

Figure 6
CO-AUTHORSHIP AND COUNTRIES WITH ASSOCIATION STRENGTH



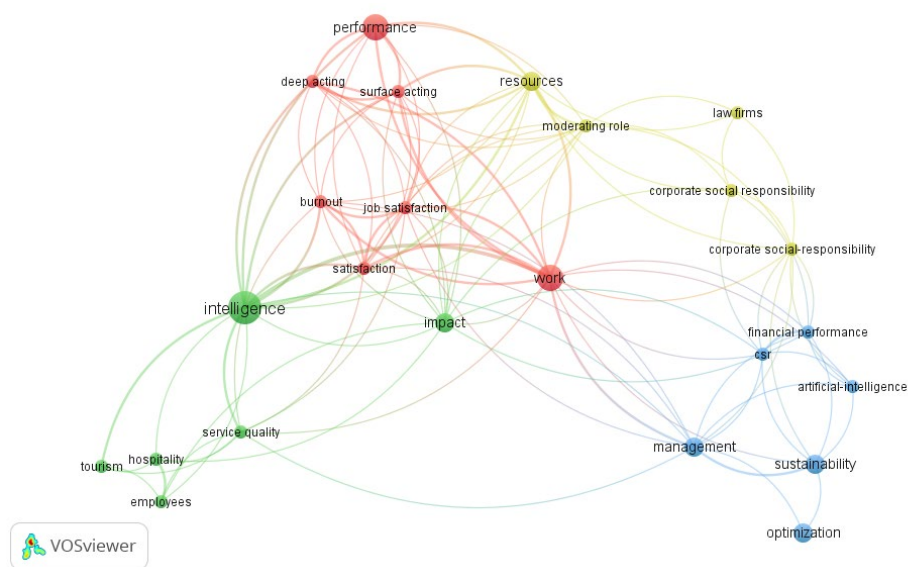
Note: network visualizations based on document weights.

4.2.4. Co-occurrence analysis of keywords

Using VOSviewer software a network map of shared words based on bibliographic data of publications indexed in the Web of Science database was constructed. These network maps enable researchers to identify clusters of related terms, central keywords, and patterns of co-occurrence, offering valuable insights into the underlying themes and topics present in the literature (Dziurakh *et al.*, 2024; Van Eck and Waltman, 2010). The analysis co-occurrence of all keywords with the counting method and minimum number of occurrences of a keyword 2 shows that out of the 257 keywords, 21 meet the threshold. For each of the 24 keywords, the total strength of the co-occurrence link with another keyword is calculated.

The keywords with the highest total link strength are shown in 4 clusters. *Cluster 1* in red with 7 items (Burnout, Deep acting, Job satisfaction, Performance, Satisfaction, Surface acting, Work), *Cluster 2* in green with 6 items (Employees, Hospitality, Impact, Intelligence, Service quality, Tourism), *Cluster 3* in blue with 6 items (Artificial intelligence, CSR, Financial performance, Management, Optimization, Sustainability), *Cluster 4* in yellow with 5 items (Corporate social responsibility, Corporate social-responsibility, Law firms, Moderating role, and Resources), see Figure 7. In addition, the five most frequently occurring keywords included performance and work (cluster 1), intelligence (cluster 2), sustainability (cluster 3), and resources (cluster 4), among others (see Table 6)

Figure 7
CO-OCCURRENCE OF ALL KEYWORDS WITH ASSOCIATION STRENGTH



Note: network visualizations based on document weights.

In considering Keywords related to the utilization of artificial intelligence in sustainable tourism can be grouped into four clusters, which represent the main research directions in this field. The characteristics of these clusters are presented in Table 6.

The first red cluster named “Work” encompasses research related to the realm of artificial intelligence (AI) in sustainable tourism. It encompasses the tasks, responsibilities, and activities undertaken by individuals within the tourism industry, which AI aims to optimize through automation, efficiency, and personalized experiences, contributing to sustainable practices and enhanced customer satisfaction. Burnout refers to the emotional exhaustion and decreased personal accomplishment experienced by employees due to prolonged stress and workload. “Deep acting” involves the genuine expression of emotions to meet job

demands, contrasting with surface acting, which involves faking emotions to conform to organizational expectations. “Job satisfaction” reflects employees’ contentment and fulfillment with their roles, while “Performance assesses” the effectiveness and productivity of tasks completed. “Satisfaction” pertains to the overall happiness and contentment experienced by employees in their work environment. “Surface acting” refers to the superficial display of emotions to meet job requirements, often to conform to organizational expectations rather than genuinely expressing feelings.

The second cluster named “Intelligence” indicates a profound connection between the capability of AI and make informed decisions. It refers to the capability of AI systems to analyze data and make informed decisions. “Employees” in this context are individuals within the tourism sector whose roles and tasks may be augmented or streamlined by AI technologies, allowing them to focus on providing high-quality hospitality services and enhancing guest experiences. This technology “Impacts” “Employees” by automating repetitive tasks allowing them to focus on enhancing hospitality and service quality. “Hospitality” encompasses the provision of personalized and efficient services to tourists, facilitated by AI’s ability to tailor experiences and streamline operations, as it can lead to improved “Service quality” practices and contribute to the long-term viability of the “Tourism” industry.

The items included in the clusters are items mainly related to consumer satisfaction and perception, and items related to the impact of AI on tourism workers, which leads us to accept hypotheses 4 and 5. The third blue cluster named “Management” includes research related to the development and management of modern information-based strategies for sustainable tourism. It involves the strategic planning, organization and coordination of resources and activities within tourism businesses to effectively achieve sustainability goals. “AI” refers to the use of advanced technologies to improve various aspects of the tourism industry, such as customer service, resource management, and operational efficiency, with a focus on promoting sustainability. “Corporate Social Responsibility (CSR)” encompasses the ethical and socially responsible practices adopted by tourism businesses to minimize negative impacts on the environment, society and local communities, while maximizing positive contributions. “Financial performance” assesses the economic viability and profitability of tourism businesses, taking into account both traditional financial metrics and sustainability indicators. Optimization involves the use of AI and data analytics to streamline processes, allocate resources efficiently and maximize outcomes, contributing to both economic efficiency and environmental sustainability in tourism operations. “Sustainability” refers to the long-term balance between environmental protection, socio-cultural preservation, and economic development in tourism destinations, with AI playing a critical role in facilitating sustainable practices and outcomes.

The four yellow clusters named “Resources” focus on research involving optimize the utilization of resources in sustainable tourism in enhancing CSR practices and the regulatory frameworks associated with AI technologies in the tourism sector such as intellectual property rights, and liabilities issues.

AI can optimize the use of “Resources” in sustainable tourism by analyzing data to identify inefficiencies, and reduce waste. A “moderating role” by facilitating decision-making processes and providing real-time insights to stakeholders. It can help balance the interests of different stakeholders, including tourists, businesses and local communities, to ensure sustainable outcomes.

“Corporate Social Responsibility (CSR)” can enable tourism businesses to monitor and improve their environmental, social, and economic impacts, leading to more responsible and ethical operations, and “Law firms” may have a role in advising tourism businesses on legal compliance, risk management, and ethical considerations related to AI implementation in sustainable tourism.

In summary, the third cluster relates AI to social, environmental and financial performance. Furthermore, this cluster shows that the inclusion of AI in tourism is creating a new paradigm that affects the processes and management of the sector. This allows us to accept hypothesis 6, the implementation of AI in sustainable tourism is creating social, environmental, and financial value.

Table 6
CO-OCCURRENCE OF ALL KEYWORDS WITH ASSOCIATION STRENGTH

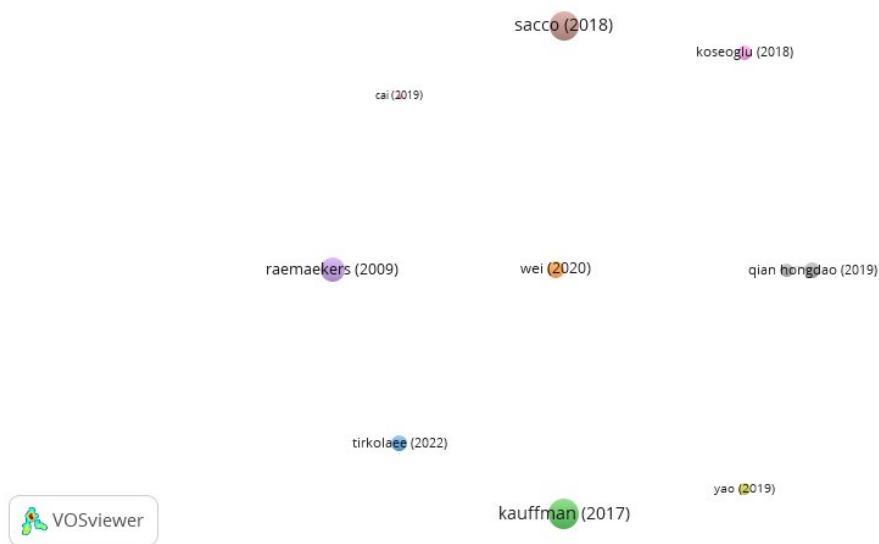
Keyword	Occurrences	Total link strength	Average Pub Year	Cluster
Work	4	27	2021	1
Intelligence	5	26	2020	2
Resources	3	19	2019	4
Burnout	2	16	2021	1
Job satisfaction	2	16	2021	1
Satisfaction	2	16	2021	1
Deep acting	2	15	2020	1
Impact	3	15	2020	2
Performance	4	15	2019	1
Surface acting	2	15	2020	1
Management	3	14	2021	3
Moderating role	2	14	2020	4
Corporate social-responsability	2	10	2020	4
Service quality	2	10	2021	2
Crs	2	9	2021	3
Financial performance	2	9	2021	3
Sustainability	3	8	2017	3
Corporate social responsibility	2	7	2019	4
Artificial-intelligence	2	6	2021	3
Employees	2	6	2021	2
Hospitality	2	6	2021	2
Tourism	2	5	2020	2
Law firms	2	4	2019	4
Optimization	3	2	2018	3

4.2.5. Citation analysis

The analysis citation regarding documents with minimum number of citations of a document 3, for each of the documents the number of citation links is calculated. The results show that out of the 24 documents 10 meet the threshold (see Figure 8).

The citations with the highest total link strength are represented in 9 Clusters. The largest Cluster is the one with the largest number of citations, in this case, it is Cluster 2 in green (Kauffman, 2017) with 23 citations. Cluster 1 in grey with 2 items (Hongdao, 2019; Qian Hongdao, 2019), Cluster 2 in green with 1 item (Kauffman, 2017), Cluster 3 in blue with 1 item (Tirkolae, 2022), Cluster 4 in yellow with 1 item (Yao, 2019), Cluster 5 in purple with 1 item (Raemaekers, 2009), Cluster 6 in red with 1 item (Cai, 2019), Cluster 7 in orange with 1 item (Wei, 2020), Cluster 8 in brown with 1 item (Sacco, 2018), Cluster 9 in pink with 1 item (Koseoglu, 2018) see Figure 8.

Figure 8
CITATION OF DOCUMENTS



Note: network visualizations based on document weights.

In terms of the bibliographic linkage analysis of journals, considering a minimum threshold per journal is considered. Table 7 presents the top journals in terms of link strength. It should be noted that Electronic Commerce Research and Applications and Sustainability is far from other journals that are the most influential in the field of artificial intelligence in sustainable tourism.

Table 7
CITATION OF DOCUMENTS

Document	Citations	Links	Source	Cluster
Hongdao (2019)	10	1	Sustainability, 11(4)	1
Qian Hongdao (2019)	12	1	Sustainability, 11(12)	1
Kauffman (2017)	23	0	Electronic Commerce Research and App. 25	2
Tirkolae (2022)	12	0	Journal of Cleaner Production, 333	3
Yao (2019)	9	0	Sustainability, 11(23)	4
Raemaekers (2009)	18	0	Fisheries Research, 97(3)	5
Cai (2019)	3	0	Sustainability, 11(23)	6
Wei (2020)	13	0	Sustainability, 12(18)	7
Sacco (2018)	22	0	Sustainability, 10(11)	8
Koseoglu (2018)	11	0	Journal of Hospitality Mark. and M., 27(5)	9

The first five most cited scientific publications on the topic of AI in sustainable tourism are presented in Table 8.

Table 8
MOST CITED SCIENTIFIC PUBLICATIONS ON THE TOPIC

Document title	Authors	Countries	Cited by
Designing a sustainable closed-loop supply chain network of face masks during the COVID-19 pandemic: Pareto-based algorithms.	Tirkolae , E. B., Goli, A., Ghasemi, P., and Goodarzian, F.	Istanbul, Turkey	185
From Culture 1.0 to Culture 3.0: Three Socio-Technical Regimes of Social and Economic Value Creation through Culture, and Their Impact on European Cohesion Policies.	Sacco , P.L.; Ferilli, G.; Tavano Blessi, G.	Milano, Italy	109
Combining machine-based and econometrics methods for policy analytics insights	Kauffman , R., Kim, K., Tom Lee., S., Hoang A., Ren, J.	Singapore (Asia)	63
Profile of the illegal abalone fishery (<i>Haliotis midae</i>) in the Eastern Cape Province, South Africa: Organised pillage and management failure.	Raemaekers , S. J. P., and Britz, P. J.	Cape Town, South Africa	53

Document title	Authors	Countries	Cited by
Legal Technologies in Action: The Future of the Legal Market in Light of Disruptive Innovations	Hongdao, Q. ; Bibi, S.; Khan, A.; Ardito, L.; Khaskheli, M.	Zhejiang, China	46
Effects of Corporate Social Responsibility on Firm Performance: Does Customer Satisfaction Matter?	Wei, A. , Peng, C., Huang, H., Yeh, S.	Zhuhai, China	39

5. CONCLUSIONS

The study contributes to the literature on AI by analyzing its use in sustainable tourism. This research article analyses the last two decades of literature on artificial intelligence and sustainable tourism. The bibliometric analysis allows visualizing large bibliometric maps (e.g., number of publications and number of citations, co-authorship analysis, most active institutions contributing to publications on the topic, countries, network maps, keyword co-occurrence analysis, and citation analysis) and identifies the main thematic directions and trends in research on the application of AI in sustainable tourism. Important conclusions can be drawn from the bibliometric analysis.

For instance, according to the co-occurrence of all keywords with association strength with each cluster, there were 4 clusters (Work, Intelligence, Resources, and Management). It makes sense that the clusters 'Work' and 'Intelligence' have the highest total association strength with 27 and 26 respectively. This means optimizing the quality and efficiency of work through the analysis and improvement of AI (on data search, collection and processing). This role becomes crucial in refining the process of business with a strategic focus on sustainable development for the tourism industry. Keyword identification helps to uncover connections and relationships between different concepts and issues within a field of study.

Firstly, the study shows that the main issues investigated are the impacts of AI. Mostly, issues related to the satisfaction and well-being of two main groups are studied: employees and consumers, studying issues such as burnout, job satisfaction, satisfaction, or service quality. The study of these issues highlights the advantages and disadvantages of implementing AI in sustainable tourism. As an advantage, AI has been shown as a system that has enabled the efficient consumption and use of resources in the sector (Casteleiro-Roca *et al.*, 2019). AI devices have been widely used to deliver frontline services, streamline processes, and engage consumers in value creation during service delivery (Buhalis, 2020; Chi *et al.*, 2020). In this sense, artificial intelligence is proving to be an effective tool for making tourism a more sustainable sector. However, on the downside, the literature has shown that AI undermines the tourism experience (Go and Kang, 2023). Thus, for example, the literature shows how AI in the sector can include privacy issues, inefficient and flawed systems, and the elimination of the human contact so valued in some services (Townsend, 2017). Moreover, the implementation of AI is a challenge in the tourism sector as it involves transforming structures, processes, and practices (Buhalis, 2020).

Secondly, we note that the time factor influences research on artificial intelligence. Studies have increased their interest in the use of artificial intelligence mainly in recent years and in the period (2017-2022). From 2019 onwards, and after the COVID-19 period, interest in AI in the tourism sector increased exponentially. This may be due, on the one hand, to the fact that in recent years this technology has been developed and applied to a greater extent in the tourism sector, which has attracted the interest of researchers in this field. On the other hand, the COVID-19 crisis has highlighted the important role of technologies in the provision of services, and organization of processes and has awakened an interest in their application in contact with people and the search for efficiency in the use of resources.

Thirdly, the study highlights that research on AI in sustainable tourism is in its early stages. This is evidenced by the small number of authors and institutions where this research topic is analyzed. There is a concentration of studies per author and institution.

Fourthly, the area factor, also highlights the cultural differences between the countries that analyze this subject, universities on the European continent and in the East.

The bibliometric analysis highlights that there are important gaps in the literature that need to be addressed. First, not only the impacts but also the determinants that lead to the implementation of these systems as sustainability tools in the tourism sector need to be studied in greater depth. In this respect, studies on the relationship between IA and CSR in tourism companies can be developed. Second, it seems necessary to study the effect of the implementation of AI in the tourism sector, not only on employees and consumers but also on other stakeholders involved, such as suppliers, investors, or society in general. Third, given that time and place are variables that condition studies on AI and sustainable tourism, it would be convenient to analyze the influence of variables such as country or the use of AI in COVID-19 times. Fourth, future studies could also analyze the effect of culture on the use of AI (Kelly *et al.*, 2023). Moreover, the study informs the formulation of relevant scientific questions and identifies promising directions for development, including Artificial Intelligence (AI), Blockchain, Internet of Things (IoT), Augmented Reality (AR), and Virtual Reality (VR) technologies. By pinpointing shortcomings and opportunities, researchers and industry practitioners can devise effective strategies for AI implementation.

Based on the above argument, AI technologies in sustainable tourism aim to optimize work processes and enhance job satisfaction and performance by automating tasks, providing personalized customer experiences, and facilitating efficient resource allocation, ultimately contributing to employee satisfaction and well-being. Ultimately, AI in sustainable tourism aims to ensure that tourism activities are conducted in a responsible and environmentally conscious manner, such as controlling resource consumption (e.g., water, energy) is now a sustainable tourism challenge for all governments benefiting both travelers and destination communities alike.

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Arco Castro and Paola Marcela Hermosa Del Vasto. Methodology: Paola Marcela Hermosa Del Vasto.

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