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ARTIFICIAL INTELLIGENCE AND SUSTAINABILITY IN SMALL AND MEDIUM TOURISM ENTERPRISES (SMTES): A BIBLIOMETRIC REVIEW OF THEIR INTERPLAY

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Abstract: This study examines the impact of artificial intelligence (AI) on the sustainability of small to medium-sized tourism enterprises (SMTEs) through an extensive bibliometric analysis of research conducted between 2014 and 2025. The goal is to identify prevailing trends, challenges, and opportunities related to AI integration in the tourism sector, especially concerning SMTEs. Given the rapid advancements in AI-driven technologies, the study also highlights the increasing role of generative AI models in content creation to enhance customer interactions and emphasizes the need for designing and evaluating AI tools tailored to address the constraints faced by SMTEs. A bibliometric study was conducted using the Scopus database, narrowing an initial set of 643 records down to 373 relevant articles. VOS Viewer software (v1.6.20) was used to map publication trends, country contributions, journal outlets, author collaborations, and thematic clusters. To provide a comprehensive overview of the field, the study combined network analysis and thematic analysis. The results indicate a steady increase in publications over the study period, with a notable acceleration after around 2019. International collaboration is also growing, reflecting increased global interest in AI and sustainable tourism. However, despite this growth, only a small portion of studies explicitly focus on SMTEs; most research either addresses larger tourism enterprises or applies generalized models that do not account for SMTE-specific constraints and contexts. The study emphasizes the need for ongoing research to ensure AI tools are used in ways that foster innovation and sustainability within specific types or niche SMTEs, while developing and evaluating AI tools that are affordable, scalable, and responsive to their constraints.

Keywords: artificial intelligence, digital technology, digitalisation, sustainable tourism, small and medium tourism enterprises

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INTRODUCTION

The proliferation and use of emerging digital technologies like artificial intelligence (AI) have transformed businesses worldwide, and this cannot be overlooked. To examine this phenomenon, the authors conducted a bibliometric analysis of AI's applications, opportunities/benefits, setbacks, and perspectives on achieving socioeconomic development, while also enhancing our understanding of how technology can support sustainability in tourism. The analysis investigates the interaction between AI-driven technologies and how their use could foster the much-needed innovation to promote sustainability within small and medium tourism enterprises (SMTEs). Clearly, AI has grown increasingly important in automating processes in the global business landscape and the tourism sector (Zhang et al., 2025).

Tourism remains a key sector driving socioeconomic development worldwide. Typically, it is expected that businesses of various sizes, especially SMTEs within the industry, would leverage these opportunities to expand their enterprises, thereby boosting economic growth (Phoofolo & Ndlovu, 2024). However, SMTEs often underperform due to numerous challenges, primarily their failure to effectively incorporate digitalization into their operations (Ndlovu et al., 2025). These SMTEs remain on the fringes of the digital landscape, and to their detriment, they are frequently absent from the tourism supply chain network. As a result, the sector frequently struggles to meet the constantly changing needs and expectations of tourists (Miguel-Ángel & Grilló-Méndez, 2023). This ongoing issue continues to hinder SMTEs' efforts to optimize operations, enhance competitiveness, increase profitability, and ensure sustainability (Bujdosó et al., 2025).

However, digital technologies have become essential, driven by easy 'quick wins' such as chatbots, automated marketing, energy optimisation, and by generative-AI tools (ChatGPT) for customer communication (López-Naranjo et al., 2025). The widespread use of AI-driven tools has transformed the way SMTEs and customers interact, with reported benefits such as improved customer personalisation, operational efficiency, pricing and distribution, and increased revenue (Ayinaddis, 2025). Notably, these benefits vary by capability and context. For example, interaction between organizations has become automated, while digital platforms have changed the way tourists plan, search for information, and experience their trips (Henriques et al., 2024). Recently, tourists have become more tech-savvy and often search for destinations online using advanced digital tools. This has increased interest among SMTEs to incorporate artificial

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intelligence into their operations to stay current with the rapidly changing digital landscape and the varied demands of customers. AI is widely applied and has the potential to revolutionize the tourism industry by enabling seamless interactions between SMTEs and other entities, resulting in more memorable travel experiences (Bulchand-Gidumal et al., 2023; Majan et al., 2024). Tools like chatbots, voice assistants, Google Maps, travel helpers, robots, and ChatGPT can help develop personalized services to boost customer or tourist satisfaction (Florido-Benítez & del Alcázar-Martínez, 2024). Additionally, machine learning and deep learning are vital AI tools with analytical and predictive powers to forecast future tourist arrivals and understand behaviours at travel destinations (Putri et al., 2025).

AI plays a transformative role in enhancing tourism sustainability. The adoption of AI-driven tools by SMTEs is associated with better outcomes across all three sustainability artefacts (Chiwaridzo & Masengu, 2024). Digital tools, such as robotics and generative AI tools, can enhance SMTEs' operational and economic performance in their quest for improved socio-economic and environmental sustainability (Wang & Zhang, 2025). Further, AI-driven digital tools help with information systems to guide tourists and project future tourist inflows, a phenomenon that helps mitigate against overtourism (Kumari et al., 2024). In an attempt to address tourism sustainability issues, AI tools have somewhat enhanced operational efficiency, better decision-making processes, customer experience, streamlined supply chains, and contributed to poverty reduction (Nwagbala et al., 2025). In essence, AI and tourism sustainability are embedded in establishing a balance in improving the way of life, continuity of business, and the preservation of natural resources and the ecosystem (Gössling & Mei, 2025). In realising integrative sustainable practices, adopting sustainable practices driven by AI tools is essential for SMTEs in enhancing customer experience, global visibility, socio-economic development, and resource efficiency for long-term success (Badghish & Soomro, 2024). Ultimately, AI automated processes foster innovativeness critical for promoting performance and sustainability in SMTEs (Al-Romeedy & Alharethi, 2024). Despite these potential benefits, the adoption rate of AI among SMTEs in the context of developing countries remains low due to setbacks such as insufficient digital literacy, limited access to the digital space, high implementation costs, and digital privacy and security concerns (Song & Chen, 2025).

However, this bibliometric analysis seeks to emphasize the need for designing and evaluating AI tools tailored to address constraints associated with SMTEs. The study quantifies AI-related publications on sustainability in SMTEs, identifies and analyses relevant topics, and develops a thematic map of articles on AI-digital-driven technologies. In the process, the analysis (a) explores the literature, affordance theory, and identifies the main contributors in the domains of AI-driven technologies and sustainability in SMTEs, (b) explores commonalities and peculiarities among various stages of research developments, and (c) explores the opportunities and benefits of AI and sustainability in SMTEs.

LITERATURE REVIEW

AI refers to the system that simulates human intelligence characteristics, a machine programmed to think, mimic, and perform tasks ordinarily requiring human intelligence, such as speech recognition, visual recognition, predictions, and decision making (Buhalis et al., 2019). It encompasses the development of computer applications that can process big data analytics with the capacity to make future predictions, analyse trends, and decision-making utilising data (Henriques et al., 2024); thus, there is a consensus or convergence of ideas in defining AI. Artificial Intelligence-enabled applications, smartphones, and other portable digital devices have significantly contributed to the tourism industry by presenting innovative ways to address constantly changing clients' demands (Doğan & Niyet, 2024). It enables and enhances accessibility, communication, and interactivity among key stakeholders, a phenomenon vital to transformation and sustainability in SMTEs (Siddik et al., 2025). Through AI-driven applications, the tourism industry can achieve significant operational transformation. This is accomplished by gaining insights into future tourist experiences, understanding individual and group behaviours in specific areas, accurately projecting visitor numbers, and fully planning the tourism supply chain resources, such as staffing and provisions, all leading to superior resource utilization (Milton, 2023).

They have revolutionised the tourism industry by helping entities create personalized services that meet tourists' expectations and increasing visitors' willingness to adopt new technologies in search of destinations (Florido-Benítez & del Alcázar Martínez, 2024). Moreover, AI-powered applications analyse data and project future market trends and fluctuations in tourist inflows. This enables businesses to adjust inventory and resource allocation, reducing waste and improving efficiency benefits that might not have been achievable without artificial intelligence (Hussain & Arsalan, 2024). In particular, AI has proven useful in the tourism industry by allowing entities to process large volumes of data effectively.

In planning a visit, tourists need information about choosing a destination, booking transport, and making accommodation reservations (Buhalis et al, 2019). These decisions have a long-lasting impact on the entire trip, and if tourists are satisfied, the likelihood of a repeat visit is almost guaranteed. Moreover, AI applications have transformed entities by monitoring inventory, deliveries, and tracking resources in real-time, thereby enhancing decision-making, value creation, and sustainability. It offers an eco-friendly transportation system, with smart travel assistants suggesting alternative routes, which reduces frustrations caused by traffic congestion. However, AI-powered platforms and applications have excited tourists and organizations through their ability to provide personalized services, efficiency, and convenience, which should be a priority for many SMTEs. Additionally, it enables quality interaction between service providers and clients, thus accelerating the use of the digital space toward smart tourism. Given the increasing use of robotics in other parts of the economy (Hermosa & Castro, 2024), adopting AI-tracking robots will boost efficiency and sustainability in tourism. For example, countries like the USA, China, and Japan have excelled in robotics across many sectors (Del Vasto, & Castro, 2024). AI-driven robots can support tasks and, more importantly, perform jobs that are difficult for humans. For instance, AI-powered drones providing real-time data can be used in wildlife conservation and environmental impact

assessments, covering large areas that would be challenging for humans to manage (Mangewa et al., 2019). Digital wildlife surveillance helps assess animal behaviour and monitor grazing areas and water points (Essen et al., 2023). Chatbots, an AI application that uses text and speech, can assist tourists with booking accommodations like Airbnb and are available 24/7.

Bibliometric Analysis

A bibliometric analysis study was used, focusing on the quantitative and qualitative facets of the relevant literature (Baker et al., 2020). The bibliometric analysis method consists of identifying, organising, and analysing the main concepts forming the foundation of the study. The data extraction process for the bibliometrics analysis was performed in Figure 1 using the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) procedure, taking into consideration the key domain methods of identifying, selecting, assessing, and synthesising (Page et al., 2021). The identification process, thus extracting from Scopus articles, generated 643 records. The screening process was conducted, eliminating 12 articles in the initial screening process of titles, abstracts, and keywords, for the time frame from 2014-2025. Between 2014 and 2025, there has been a notable acceleration in AI-driven applications within the tourism sector. AI has been significant in enhancing sustainability in the tourism sector, thus optimising decision-making, supply chain, and improving visitor experiences. These advancements underscore the transformative role of AI in promoting tourism sustainability. However, assessing for eligibility, 258 records were further excluded based on subject area, source type, and the English language.

The subject area was limited to social sciences, business management, computer sciences, environmental sciences, and economics. Whereas on the source types, the analysis was limited to articles, conference papers, book chapters, books, and review papers. The final database comprised 373 articles that were exported in plain text format, the 'comma-separated values' CSV file for bibliometric analysis. The file was assessed for possible duplicate articles before computing the bibliometric analysis. Bibliometric analysis is significant in the assessment and evaluation of the development of knowledge. The statistical tools and network analysis augment our understanding of the subject matter (Deyanova et al., 2022). In the process, the publication by type, the year of publication, the subject area, the publication country, and the keywords are included in the analysis through the VOSviewer software. The database was obtained from Scopus, one of the most widely used databases of peer-reviewed literature, and Elsevier owns it. The database was derived through the search functions in selecting database=Scopus Science; Topic=TITLE-ABS-KEY ("Artificial Intelligence" OR "Machine learning" OR "Deep learning" OR "Digital" AND "Sustainable tourism" OR " Small tourism businesses"). The search criteria covered the title, abstract, and keywords of articles. The refining search of results involved filters, and it was limited to articles in the English language.

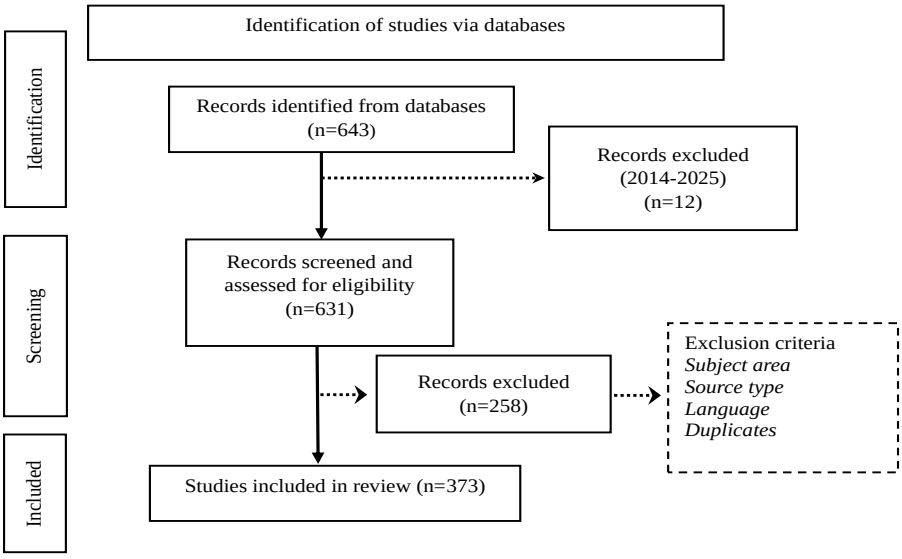

Figure 1. Search results according to the PRISMA flowchart (Source: BMJ (2021)

ANALYSIS AND RESULTS

This bibliometric analysis (citation, co-citation, co-authorship, bibliographic coupling) was used to examine the relationship among research artifacts, and a full counting method was applied. Bibliographic coupling and co-authorship were applied to assess collaborative relationships among authors from different affiliations and countries. Citation analysis, speaking to popular articles within the network, and co-citation analysis of networks of the various sources were used to identify the most influential subject within the selected themes. Co-occurrence analysis of keywords was also done to establish the most popular topics within the selected themes.

Publication by type

The evidence points to the fact that many researchers are more inclined to publish research articles in the field concerned.

Table 1. Publication by type in percentages (Source: Authors)

Articles	Conference papers	Book chapters	Reviews
55.8	24	16.4	3.8

Literature Trends by Year

Figure 2 depicts the number of scholarly articles published yearly from 2014 to 2025. The graph shows that there was a noteworthy steady increase in the number of research articles in 2020. The significant annual output was recorded in 2024, with 2025 already showing indicators of exponential growth.

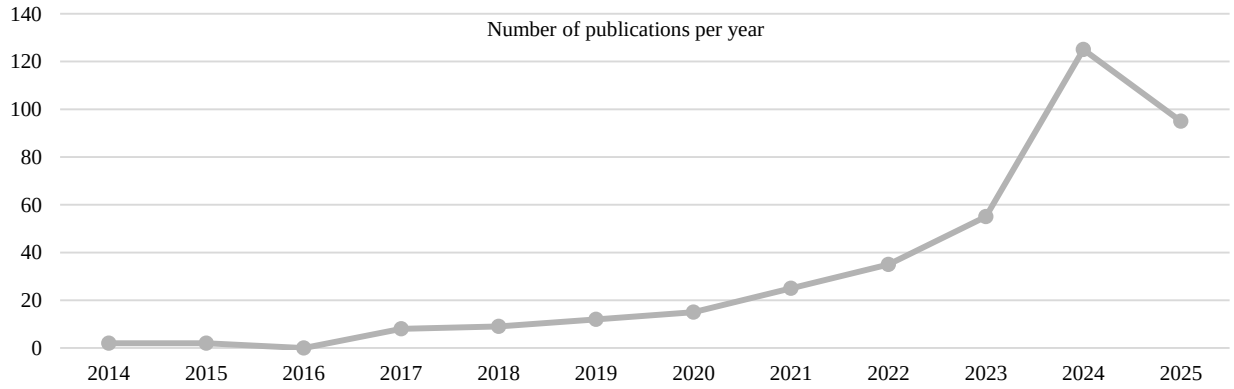

Figure 2. Publication by year (Source: Authors)

Most Impactful Authors

Table 2 depicts the impact of the top 21 articles published by authors. Thus, through total citations and rankings.

The fact that Della Corte et al. (2019), Xiao et al. (2018), and Herrera-Franco et al. (2021) dominate the citation counts suggests that research in AI and tourism sustainability is currently heavily shaped by what is regarded as significant, such as smart infrastructure and predictive analytics. However, this may lead to under-attention to other areas such as community engagement or the development of low-technology AI, which is context-specific.

Table 2. Most Impactful Authors (Source: Authors)

Author name	Total Citation	Rank
Galati, A., Thrassou, A., Christofi, M., Vrontis, D. & Migliore, G. (2023)	54	15
Alsahafi, R., Alzahrani, A. & Mehmood, R. (2023)	47	17
Rahmadian, E., Feitosa, D. & Zwitter, A. (2023)	87	8
Sultan, M.T., Sharmin, F., Badulescu, A., Stiubea, E. & Xue, K. (2021)	75	10
Mou, N., Zheng, Y., Makkonen, T., Yang, T., Tang, J., & Song, Y. (2020)	116	4
López-Sánchez, Y., & Pulido-Fernández J. I. (2017)	56	14
Nilashi, M., Ahani, A., Esfahani, M.D., Yadegaridehkordi, E., Samad, S., Ibrahim, O., Sharef, N.M. & Akbari, E. (2019)	116	4
Herrera-Franco, G., Montalván-Burbano, N., Carrión-Mero, P., Jaya-Montalvo, M., & Gurumendi-Noriega, M. (2021)	120	3
Tan, W.J., Yang, C.F., Château, P.A., Lee M.T. & Chang, Y.C. (2018)	69	12
Xiao, W., Mills, J., Guidi, G., Rodríguez-Gonzálvez, P., Gonizzi Barsanti, S., & González-Aguilera, D. (2018)	148	2
Romanelli, M., Gazzola, P., Grechi, D. & Pollice, F. (2021)	48	16
Tussyadiah, I. & Miller, G. (2019)	88	7
Del Vecchio, P., Mele, G., Ndou, V. & Secundo, G. (2018)	84	9
Loureiro, S.M.C., & Nascimento, J. (2021)	62	13
Ponnapureddy, S., Priskin, J., Ohnmacht, T., Vinzenz, F. & Wirth, W. (2017)	88	7
Tiago, F., Gil, A., Stemberger, S., & Borges-Tiago, T. (2021)	88	7
Van, N. T. T., Vrana, V., Duy, N. T., Minh, D. X. H., Dzung, P. T., Mondal, S. R., & Das, S. (2020)	94	6
Camatti, N., Bertocchi, D., Carić, H., & van der Borg, J. (2020)	45	18
Tham, A. & Sigala, M. (2020)	74	11
Kuzior, A., Lyulyov, O., Pimonenko, T., Kwilinski, A. & Krawczyk, D. (2021)	99	5
Della Corte, V., Del Gaudio, G., Sepe, F. & Sciarelli, F. (2019)	179	1

Highly Cited Publications

Table 3 lists the most influential publications on the interplay between artificial intelligence and sustainability in small and medium tourism enterprises (SMTEs). Della Corte et al. (2019) authored the most cited article with 179 citations, followed by Xiao et al. (2018) with 148 citations, and Herrera-Franco et al. (2021) with 120 citations. Through an extensive literature review, Della Corte et al. (2019) state that artificial intelligence-driven technologies play an important role in resource sustainability. Notably, AI has significantly contributed to tourism marketing through reengineering processes that enable information to drive competitiveness (Kuzior et al., 2021). It has improved interactivity between stakeholders and enterprises, thereby influencing return on investment. AI enhances supply chain networks to which the enterprise belongs, integrating business processes and transforming distribution models. Furthermore, through AI-driven applications, entities in the tourism industry can predict tourist inflow, enabling management to allocate resources sustainably. New technologies such as AI-driven applications, the Internet of Things, big data, AR, and VR are reshaping the sustainable development of tourism (Tiago et al., 2021).

Table 3. Highly Cited Publications (Source: Authors)

Author	Title	Year	Cited by	DOI/Link
Della Corte, V., Del Gaudio, G., Sepe, F. & Sciarelli, F.	Sustainable tourism in the open innovation realm: A bibliometric analysis	2019	179	https://doi.org/10.3390/su11216114
Xiao, W., Mills, J., Guidi, G., Rodríguez-Gonzálvez, P., Gonizzi Barsanti, S. & González-Aguilera, D.	Geoinformatics for the conservation and promotion of cultural heritage in support of the UN Sustainable Development Goals	2018	148	https://doi.org/10.1016/j.isprsjprs.2018.01.001
Herrera-Franco, G., Montalván-Burbano, N., Carrión-Mero, P., Jaya-Montalvo, M. & Gurumendi-Noriega, M.	Worldwide research on geoparks through bibliometric analysis	2021	120	http://doi.org/10.3390/su13031175
Nilashi, M., Ahani, A., Esfahani, M.D., Yadegaridehkordi, E., Samad, S., Ibrahim, O., Sharef, N.M. & Akbari, E.	Preference learning for eco-friendly hotels recommendation: A multi-criteria collaborative filtering approach	2019	116	http://doi.org/10.1016/j.jclepro.2019.01.012
Mou, N., Zheng, Y., Makkonen, T., Yang, T., Tang, J. & Song, Y.	Tourists' digital footprint: The spatial patterns of tourist flows in Qingdao, China	2020	116	http://doi.org/10.1016/j.tourman.2020.104151
Kuzior, A., Lyulyov, O., Pimonenko, T., Kwilinski, A. & Krawczyk, D.	Post-industrial tourism as a driver of sustainable development	2021	99	http://doi.org/10.3390/su13158145
Van, N.T.T., Vrana, V., Duy, N.T., Minh, D.X.H., Dzung, P.T., Mondal, S.R. & Das, S.	The role of human–machine interactive devices for post-COVID-19 innovative sustainable tourism in Ho Chi Minh City, Vietnam	2020	94	http://doi.org/10.3390/su12229523
Tussyadiah, I. & Miller, G.	Nudged by a robot: Responses to agency and feedback	2019	88	http://doi.org/10.1016/j.annals.2019.102752
Ponnapureddy, S., Priskin, J., Ohnmacht, T., Vinzenz, F. & Wirth, W.	The influence of trust perceptions on German tourists' intention to book a sustainable hotel: a new approach to analysing marketing information	2017	88	http://doi.org/10.1080/09669582.2016.1270953
Tiago, F., Gil, A., Stemberger, S. & Borges-Tiago, T.	Digital sustainability communication in tourism	2021	88	http://doi.org/10.1016/j.jik.2019.12.002
Rahmadian, E., Feitosa, D. & Zwitter, A.	Eco-Smart Tourism: Bridging The Gap Between High-Tech Solutions and Sustainable Hotel Management Practices	2022	87	http://doi.org/10.1080/13683500.2021.1974358

Most leading Journals

Figure 3 depicts the following: The Journal of Sustainability was the most used source with a total of 64 publications in the research area, with the highest number of citations of 1313. The Journal of Sustainable Tourism comes second with a total number of 7 publications and 263 citations, and Worldwide Hospitality and Tourism Themes with a total of 8 publications and 86 citations.

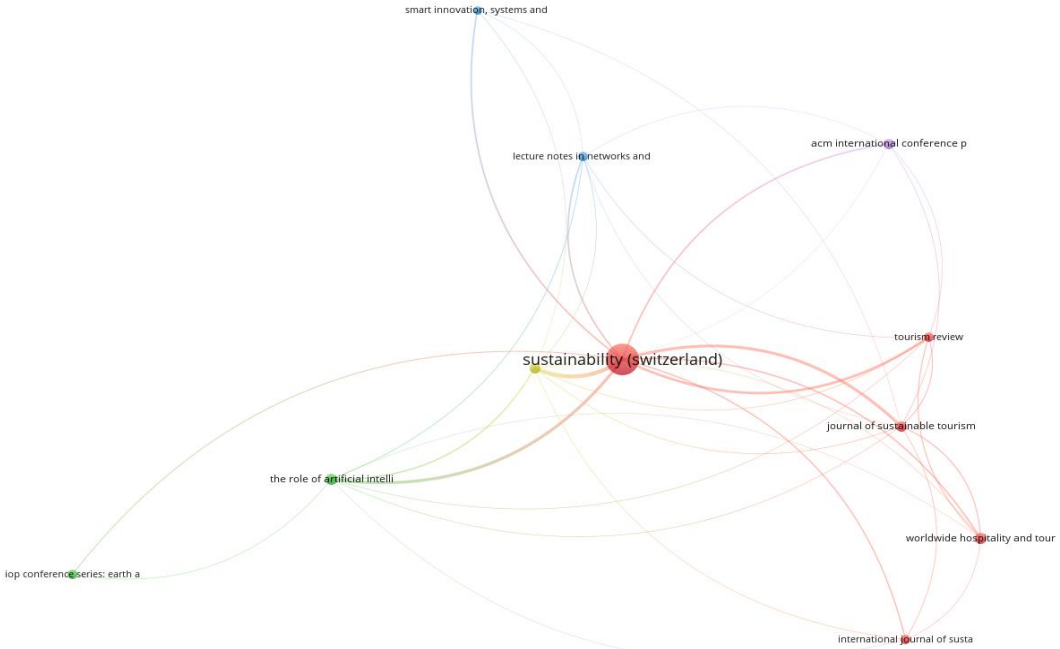

Figure 3. Most leading journals (Source: Authors)

Most of the top journals in the field of AI and tourism sustainability tend to cluster in technology-oriented, information systems, and sustainability in general. For instance, journals focused on smart technology, predictive analytics, and sustainability dominate the citation and publication network, whereas journals whose readership includes tourism policy makers, practitioners, or SMTEs are under-represented among the highly cited. This skewed presentation might present some challenges. For instance, the findings and innovations in AI may not sufficiently translate into policy or practice in SMTE contexts, particularly in areas where these small entities dominate tourism but lack access to technology

Most Leading Countries

Figure 4 shows the leading countries in the selected research themes guiding the analysis.

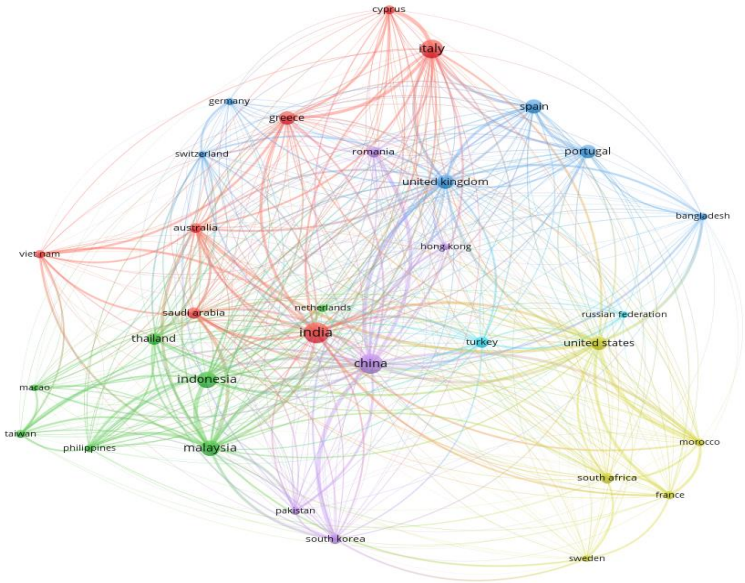

Figure 4. Most leading countries (Source: Authors)

Table 4 depicts the top 10 countries that lead in terms of the number of publications, and Table 5 shows the number of publications and the top 16 leading countries in total citations on research themes.

Table 4. The top 10 leading countries in publications on research themes (Source: Authors)

Country	Number of Articles
India	45
China	44
Italy	36
Indonesia	29
Malaysia	27
Spain	22
United Kingdom	22
United States of America	20
Portugal	20
Greece	19

Table 5. Top 16 countries leading in citations (Source: Authors)

Country	Number of Articles	Total Citations	Ranking
India	45	312	6
China	44	496	3
Italy	36	906	1
Indonesia	29	137	14
Malaysia	27	385	5
Spain	22	485	4
United Kingdom	22	575	2
United States of America	20	201	11
Portugal	20	234	10
Greece	19	269	7
Australia	11	312	6
Saudi Arabia	13	264	8
South Korea	10	148	12
Vietnam	7	238	9
Romania	12	146	13
Netherlands	6	137	14

Italy, the United Kingdom, China, Spain, and Malaysia ranked among the top 5 regarding scoring high in the total number of citations. Undoubtedly, the presence of nascent digital technologies that are AI-driven has drawn so much interest among scholars globally. The increase of studies on AI and sustainable tourism points to the shift towards improving customer satisfaction through the application of the advent of AI-technology-driven platforms that offer convenient, personalised, and seamless services. However, leading countries such as India, China, and Italy have high volume and citation impact reflecting strong research capacity, funding, and institutional emphasis. In contrast, many countries in Africa, Asia, or Latin America are underrepresented. This may suggest the need for capacity building, cross-country collaborations, or open-access strategies to optimise global diversity and relevance.

An Overview of Country Collaboration

Figure 5 shows the co-authorship association among authors' affiliated countries. The co-authorship nexus indicates that collaborations among authors from various countries are gaining momentum due to the growing fields of advancing digital technologies and tourism. 31 out of 32 countries have collaborated on the subject under review. Countries like India, China, the United Kingdom, Malaysia, Italy, and Indonesia have larger nodes in the co-authorship networks.

This shows that they are leading when it comes to co-authorship or collaborations in the subject of AI-driven technologies and sustainability in SMTEs. China comes top with total publications of 44, citations of 496, and a total link strength of 41, followed by Malaysia, with total publications of 27, citations of 385, and a total link strength of 39. Coming in the third position is the United States of America, with total publications of 20, citations of 201, and a total link strength of 31, and in fourth position is the United Kingdom, with total publications of 22, citations of 575, and a total link strength of 27. Coming in the fifth position is India with total publications of 45, citations of 312, and a total link strength of 25. However, these results suggest that AI-driven technology leaps are global.

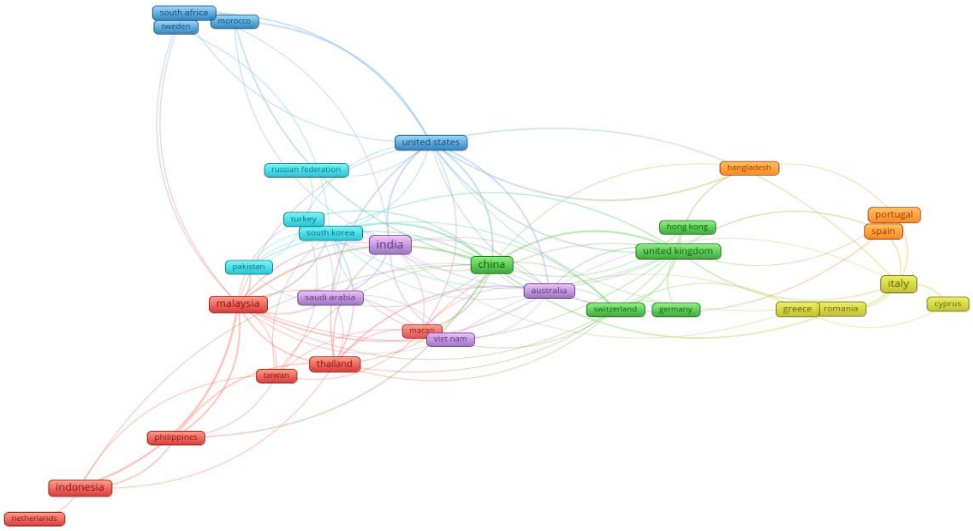

Figure 5. Country collaboration analysis [31 out of 32 countries] (Source: Authors)

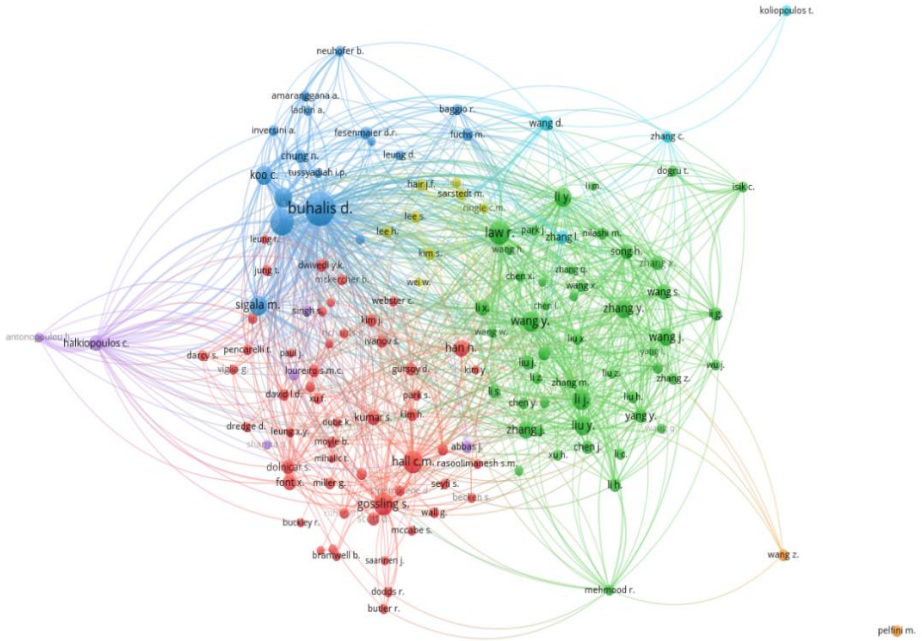

Figure 6. Co-citation of authors cited (139 of 32,388) (Source: Authors)

Co-citation of Authors Cited

Figure 6 illustrates co-citations of authors who have been cited. A total of 32,388 authors were referenced, of which 139 accumulated a minimum of 20 citations. The co-citation map displays 139 authors who meet the threshold and are arranged into seven distinct clusters. It encompasses a cumulative total link strength of 140,528. Cluster (red) consists of 52 authors, with Gosslings leading with 109 citations and a total link strength of 2,349.

Cluster (blue) consists of 17 authors, with Buhalis leading with 256 citations and a total link strength of 6572, whereas the cluster (green) consists of 50 authors, with Law leading with 128 citations and a total link strength of 3842. Cluster (purple) consists of 6 authors, with Halkiopoulos leading with 54 citations and a total link strength of 2014; cluster (gold) consists of 8 authors, with Kim leading with 37 citations and a total link strength of 954. Cluster (light blue) has 4 authors, and Wang leads with 49 citations and a corresponding total link strength of 1459; lastly, cluster (brown) has 2 authors, and Wang leads with 30 citations and a total link strength of 750.

Keyword Co-Occurrence

Table 6 presents the analysis of co-occurrences among the most frequently discussed terms or topics related to AI-driven technologies and sustainability in SMTEs from 2014 to 2025. Co-occurrences reveal connections between publications authored by different researchers. Out of 2381 keywords considered, 111 meet the minimum threshold of five occurrences. As shown in Table 6, the most frequently occurring keyword is' sustainable tourism' with 219 occurrences and a total link strength of 781, followed by' tourism' with 145 occurrences and a total link strength of 652. In third place is' ecotourism' with 98 occurrences and a total link strength of 494. ' Sustainable development' ranks fourth with 92 occurrences and a total link strength of 435, followed by' sustainability' with 69 occurrences and a total link strength of 312. In sixth place is' tourism development' with 58 occurrences and a total link strength of 299, followed by' artificial intelligence' with 52 occurrences and a total link strength of 255. At the eightieth position is' leisure' with 35 occurrences and a total link strength of 201, followed by' machine learning' with 30 occurrences and a total link strength of 135. Table 6 highlights the top 25 keywords by occurrence.

Table 6. Keyword Occurrence Analysis (Source: Authors)

Keyword	Occurrences	Total Link Strength
Sustainable tourism	219	781
Tourism	145	652
Ecotourism	98	494
Sustainable development	92	435
Sustainability	69	312
Tourism development	58	299
Artificial intelligence	52	255
Leisure	35	201
Machine learning	30	135
Tourist destination	24	132
Tourism industry	22	124
Cultural heritage	21	118
Tourism sectors	16	103
Digitization	15	93
Innovation	15	91
Digital technologies	16	90
Decision making	15	86
Sustainable tourism development	16	86
China	14	85
Cultural heritages	14	85
Stakeholder	14	84
Virtual reality	16	84
Sustainable development goal	11	83
Social media	18	81
Digitalisation	15	79

Figure 7 shows a network of 111 keywords grouped into 6 clusters. Cluster 1 (gold) contains 20 keywords, and some of the keywords include: Geographic information system, urban planning, technology adoption, spatial analysis, virtual tourism, environmental impact, heritage tourism, and cultural tourism. Cluster 2 (blue) has 20 keywords, and these include digital transformation, digital economy, digital technology, environmental technology, tourist destination, digitalization, environmental protection, sustainable development goals, and sustainable city. Cluster 3 (light blue) contains 2 keywords, namely: environmental sustainability and social sustainability.

Cluster 4 (purple) consists of 13 keywords: machine learning, artificial neural network, deep learning, tourism management, hospitality industry, decision making, overtourism, and adversarial machine learning. Cluster 5 (green) contains 23 keywords: sustainability, ecotourism, tourism development, social media, tourist destination, digitalisation, internet, digital platforms, leisure industry, and tourist market. Cluster 6 (red) has 33 keywords: sustainable tourism,

artificial intelligence, tourism, smart tourism, big data, digital tools, blockchain, technological innovation, digital marketing, information systems, information management, and technology.

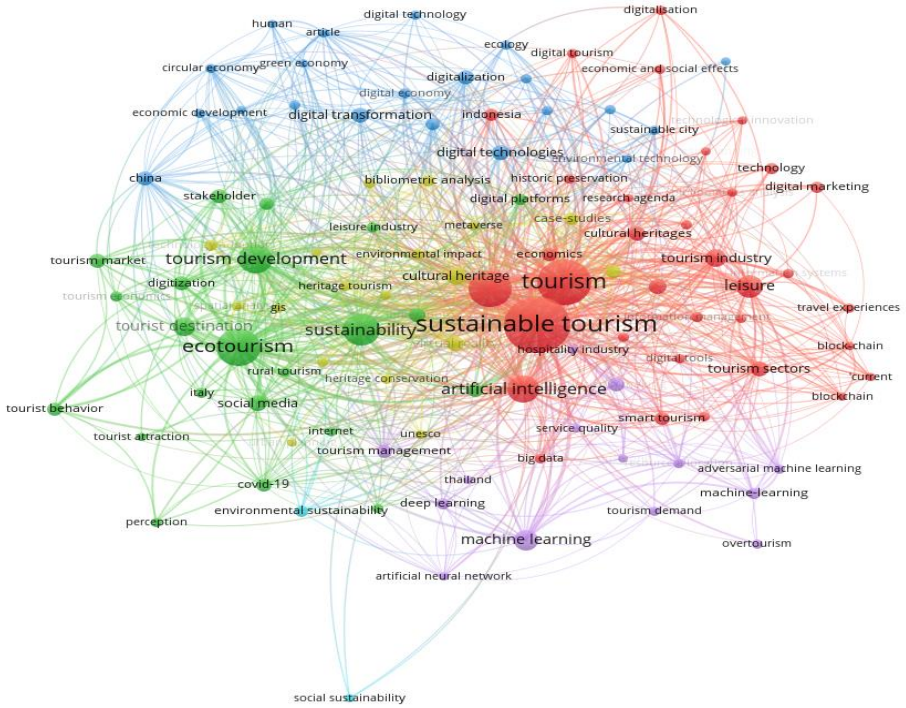

Figure 7. The Network Visualisation of Keywords [n=111] (Source: Authors)

Major Themes Related to AI-driven technologies and sustainability in SMTEs

Raman et al. (2024) posit that bibliographic coupling functions are based on the assumption that two texts referencing the same literature are likely to have similarities. A bibliographic method was adopted to condense the amount of content relating to artificial intelligence and sustainability in SMTEs into main themes.

The method groups articles based on the references they have in common. It aids in comprehending recurring themes that the journal has been focusing on (Linnenluecke et al., 2020). Through bibliographic coupling, six clusters were formed, and the study assessed the major focus of each cluster theme.

Cluster 1 Theme: Assessing the interplay between AI-driven technologies and the sustainability of heritage tourism, cultural tourism, and environmental impact

Articles in this cluster often focus on assessing the interplay between adopting technologies such as geographic information systems to enhance virtual tourism for environmental, heritage, and cultural preservation sustainability. A Geographic Information System (GIS) uses digital applications to capture, store, and perform spatial analysis of geographically referenced data. The authors focus on topics such as Geoscience popularisation in Geoparks: A common workflow for digital outcrop modelling (Williams et al., 2025), and Application of geographic information system in ecotourism: a global bibliometric analysis (Amadu et al., 2025). Whereas Šoltésová et al. (2025) looked at the Application of Geographic Information System (GIS) Technologies in Tourism Planning and Sustainable Development: A Case Study of Gelnica. Three-Dimensional Digital Geospatial Documentation for Cultural Heritage Preservation and Sustainable Management of Tourism Through a Web Platform: The Case Study of the Archaeological Park of Dion, Greece (Iliodromitis et al., 2025) is another topic the authors focused on.

The application of GIS digital tools can promote holistic nature conservation, thereby supporting geo-heritage and contributing to ecotourism sustainability. Additionally, information gathered through GIS applications can be used to provide interactive educational content and build capacity among practitioners (Williams et al., 2025). The use of GIS has significantly enhanced ecotourism through innovative technologies such as machine learning and remote sensing. These digital tools play a crucial role in facilitating better decision-making in tourism planning, management, and marketing of destinations (Amadu et al., 2025). Furthermore, GIS applications offer predictive data that enable entities to make informed decisions about resource utilisation efficiencies. By utilizing GIS, sustainable tourism can be promoted through regular impact assessments, which help curb overtourism and biodiversity loss. However, this holistic approach also reveals the dynamics and complexities involved in adopting digitalisation by small entities within the tourism sector.

Cluster 2 Theme: Assesses the digital transformation initiatives realised through the association between digitalisation, tourist destinations, and environmental sustainability.

The authors explore the relationship between digitalisation, environmental protection, and sustainable development. Some of the topics explored include: Digital twins (DT), big data governance, and sustainable tourism (Rahmadian et al., 2023), Harnessing transformational technologies for a sustainable future: A regenerative approach to green economy and

tourism development by (Sandhya et al., 2024). Other topics covered include: Digitalisation as a Driver of Sustainable Development in Tourism and Hospitality (Ndhlovu et al., 2024), and What is the transformative relationship between tourism and technology (Liasidou & Pipyros, 2025).

The introduction and adoption of nascent digital technologies have innovatively transformed and reshaped the way of doing business within the tourism industry. For instance, the use of mobile positioning data (MPD) for digital twin technology was found to promote human and machine interactions while also enhancing sustainable tourism (Rahmadian et al., 2023). Additionally, the use of technology enables the analysis of big data, which can present tourism players with information to predict travel demand, analyse customer satisfaction, and ultimately support informed decision-making. Digitalisation has led to increased information, altering the way tourists interact with destinations to the benefit of tourism actors (Ndhlovu et al., 2024). This phenomenon has led to improved efficiency while promoting socioeconomic and environmental sustainability. There has been a transformative connection between sustainability in tourism and digital technologies, particularly the way in which the concepts have innovatively reshaped the supplier-customer relationship.

Cluster 3 Theme: Assess the association between environmental sustainability and social sustainability in the tourism industry.

Modelling sustainability in tourism involves creating frameworks and strategies that address the social, economic, and environmental aspects of development. It also calls for active collaborations among all stakeholders to drive contextual developmental initiatives. The authors explore the relationship between sustainability within the tourism industry and digitalisation. For instance, Karim et al. (2025) researched the following topic: To Be Digital Is to Be Sustainable: Tourist Perceptions and Tourism Development Foster Environmental Sustainability. Other topics explored include: Digitalization means green? Linking the digital economy to environmental performance in the tourism industry (Jiang & Lv, 2025), and Delivering Extraordinary Adventure Experiences During the "Chthulucene": Circular Economy Challenges and Digital Solutions for the Environmentally Conscious Visitor (Allkins et al., 2025).

The interconnectivity of environmental sustainability and technologies enhances our understanding of the roles that communities and businesses should play in contributing to the sustainable development agenda. For instance, smart tourism destinations and social media platforms have invariably emerged as digital tools that can promote sustainable tourism practices, thereby addressing environmental sustainability. (Karim et al., 2025).

Cluster 4 Theme: The relationship between machine learning, deep learning, tourism management, decision making, overtourism, and the hospitality industry.

The authors directed their focus on the intersection between machine learning, deep learning, and sustainable tourism. Machine learning is a type of artificial intelligence focusing on the development of algorithms that can enhance task performance. For instance, predictive tasks, pattern recognition, and natural language processing. (Basirati & Laachach, 2025). The authors focus on the following topics: Clustering sustainable tourism destinations through Instagram photo analysis: a machine learning approach (Basirati & Laachach, 2025), Cultural heritage preservation in the digital age, harnessing artificial intelligence for the future: a bibliometric analysis (Harisanty et al., 2024), and Deep Learning-Based Truthful and Deceptive Hotel Reviews (Gupta et al., 2024). Another topic explored focused on the following: Machine Learning and Artificial Intelligence for Sustainable Tourism: A Case Study on Saudi Arabia (Louati et al., 2024)

Machine learning is a statistical technique embedded in AI (Louati et al., 2024). The technique enables decision-making based on predictive AI algorithms. It identifies patterns and can be used to predict tourist expenditure rates, behaviours, and preferences. This provides insights for decision-making aimed at supporting entities and other stakeholders in developing resilient and sustainable strategies for the tourism industry. Machine learning applications possess the potential of clustering sustainable tourism destinations based on user-generated content on social media (Basirati & Laachach, 2025). Thus, the ML approach could be used to analyse pictures and provide clusters for sustainable tourism. In the same vein, Gupta et al. (2024) also weighed in by suggesting that machine learning algorithms can aid in detecting false, fraudulent, and genuine hotel reviews, which is critical in decision-making.

Cluster 5 Theme: Sustainability, tourism destination, digital platforms, internet, digitalisation, tourism market, tourism development, and eco-tourism nexus.

The authors focus on eco-tourism, primarily contributing to the conservation of the natural environment through effective tourism management and exploring destinations responsibly. To realise this phenomenon, digitalisation is touted to be a panacea in the process of driving sustainability. The study by Samaana & Polukhina (2024) focused on advancing digitalization of tourism for sustainable regional development, whereas Qaid & Gowindasamy (2025) examined the social media's role in tourist engagement. Digital Solutions in Tourism as a Way to Boost Sustainable Development: Evidence from a Transition Economy is another topic (Polukhina et al., 2025) focused on. AI-driven technologies have emerged as a tool that promises solutions to business entities. Its ability to process large amounts of data in real-time and present predictions about future tourist inflows enables effective decision-making on resource planning. This has transformed the way of doing business, making entities more competitive, thereby meeting customers' expectations. For instance, the use of voice assistants and chatbots presents real-time responses to customers at the same time, reducing related human errors. Thus, digital platforms such as social media enhance easy interaction between SMTEs' actors and their customers, thereby creating repeat visits and quick feedback, ultimately promoting sustainable tourism development.

Cluster 6 Theme: The interplay between sustainable tourism, artificial intelligence, big data, technological innovation, smart tourism, digital tools, and blockchain.

The authors focus on the interplay between sustainability in tourism and various AI-driven technologies, such as big data analytics, smart tourism, and smart cities. Precisely, the authors discussed how (Fotiou et al., 2025) to enhance tourism sustainability through blockchain, AI, and smart technologies, whereas (Zhang & Cheng, 2024) focused on how AI, big data, and algorithms make it possible for stakeholders to build smart tourism destinations.

Other topics that were examined include: Integrating Artificial Intelligence (AI) into sustainable tourism management in Indonesia and the impact on customer experience (Herawati et al., 2025), and Strategic Planning for AI in Tourism Businesses: AI Tourism Start-Ups (Lari & Soare, 2025). The transformative agenda towards sustainability in tourism can be realised through the adoption and subsequent effective utilisation of AI-driven technologies. AI-driven disruptions in digital media and marketing constantly play a significant role by enabling entities to gather information about consumer behaviours and their preferences for decision-making. The fundamentals involve enhancing small to medium-sized tourism entities. For this to be possible, this analysis underscores the need for collaborative efforts among key stakeholders in creating the digital space. This digital space requires the support of affordable digital infrastructure.

The government and its proxies, and the private sector telecommunication institutions, are expected to play a critical role. This kind of support for AI-driven technologies will enable the maximisation of benefits, such as enhanced supply chain networks and interactivity with customers for improved satisfaction.

DISCUSSION

Scientific contributions to the interplay between AI-driven technologies and sustainability in SMTEs have drawn interest from many scholars and stakeholders. However, from the bibliometric analysis, indications are that the context remains underexplored, particularly in the Global South. Further, though all publications focused on sustainable tourism, the approach was rather general, lacking specificity to small and medium-sized tourism entities.

Only a few studies specifically focused on SMTEs. Specific focus on SMTEs remains critical as the absence of that may limit and affect processes associated with rescue packages, hence the need for specificity. However, during the search process, a total of 643 articles on sustainability in tourism were identified. The screening process was conducted, and 373 articles that are more relevant to the tourism industry and fall within the inclusion criteria were identified. The annual publication started to increase between 2019 to 2020, with the highest peak recorded in 2024.

Several factors could be attributed to this increase. For instance, with the advent of the COVID-19 pandemic, when travel restrictions were imposed, customers and entities had to rely on digital technologies. Additionally, the continuous development of advanced digital technologies and digital platforms has accelerated the usage of more sophisticated technologies such as AI and its related applications (Badghish & Soomro, 2024). This acceleration in AI application usage enables the processing of large amounts of information in real time, with efficiency and accuracy.

These applications are efficient, providing real-time information for decision-making and enhancing interactivity between entities and customers. Asian and European countries accelerated research in the area of AI and sustainable tourism (Louati et al., 2024). Researchers might have accelerated research on AI and sustainability to ensure that service providers offer efficient and seamless service to digitally serve customers, improve supply chain networks, and enhance the predictability of the environment for effective decision-making (Wang & Zhang, 2025).

Further, the use of AI-driven applications, such as Algorithms, enhances environmental conservation, mitigating over-tourism through its future predictive capabilities (Song & Chen, 2025), and promotes sustainable practices and socioeconomic development in communities. Lessons from global supply chain disruptions, particularly due to the pandemic, accentuated the development of advanced digital technologies toward the realisation of sustainability (Wang & Zhang, 2025). Researchers focused their investigations on promoting the resilience of entities within the tourism industry. This phenomenon has accelerated the demand for transformative initiatives driven by ubiquitous digital technologies and AI-driven applications (Erdős et al., 2025).

From a global perspective, the picture depicted indicates that more researchers in the area are from Asia and Europe, pointing to limitations in the context of developing countries. Also, the focus of the extent literature is limited in terms of entity establishment clarity. The results of the study indicate that there are a few authors contributing to leading publications. However, there has been an increase in the number of links, indicative of the importance of the subject area. For instance, the leading countries in scholarly output in the field include India, China, Italy, and Indonesia. This result is consistent with findings by Del Vasto & Castro (2024), who indicated that China, India, and the United Kingdom are among the leading countries regarding publishing on AI technologies and sustainability in tourism entities.

However, there is evidence that, thanks to AI-digital tools, SMTEs have become significant contributors to the socio-economic environment of communities, especially in developed countries where these technologies have become widespread. However, many SMTEs in developing countries still struggle to leverage AI-digital tools to improve interactivity and supply chain networks for sustainability, mainly due to limited digital infrastructure and skills in emerging technologies (Bujdosó et al., 2025).

The Conceptual contribution and theoretical implications

Failure to innovate and create online content through AI-driven digital tools platforms is one of the biggest challenges for SMTEs, hence the need for policymakers and stakeholders' collaboration in developing appropriate strategies and promoting the adoption and effective use of nascent digital tools. Figure 8 presents a conceptual framework of stakeholders' collaboration towards effective adoption and effective utilisation of AI-driven digital tools for sustainability. The bibliographic analysis suggests that what SMTEs need the most is a co-designed and co-produced

AI-digital tool to enhance interactivity, buttressed with stakeholder collaboration on digital infrastructure support and upskilling. The Unified Theory of Acceptance and Use of Technology 2 (UTAUT 2) is an extension of the original UTAUT, which aims to explain user acceptance and adoption of technology. Its key fundamental components include performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value, and habit (Venkatesh et al., 2003). The perceived usefulness, ease of use, user's influence, infrastructure support, and pleasure derived from using technology could be the stimuli towards adoption and effective utilisation.

In addition, the perceived value and habitual use of the technology enhance the adoption (Liu et al., 2024).

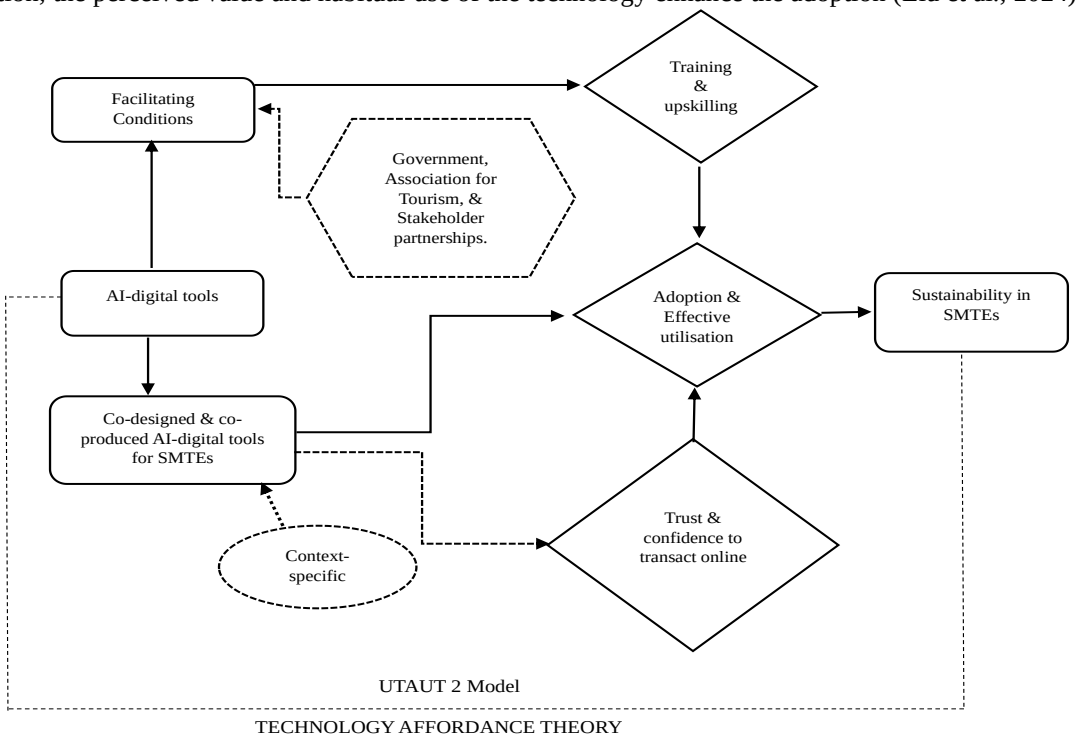

Figure 8. The conceptual framework for SMTEs' AI-digital tools adoption (Source: Authors)

CONCLUSION, IMPLICATIONS, FUTURE RESEARCH, AND LIMITATIONS

Using several bibliometric analysis indicators, the study established the influence of authors, output, and publication on AI and sustainability in tourism entities. A number of those indicators were discussed in detail, and that includes country co-authorship, productive journals, leading countries, research topics, and most cited publications. Further, results indicate that the most impactful author is Della Corte et al. (2019), 'Sustainable tourism in the open innovation realm: A bibliometric analysis,' and the Sustainability Switzerland journal is the leading source in terms of citations. Highly productive authors concerning publications are from India, China, and the United Kingdom. The results can provide valuable insights to researchers about techniques employed, thereby deepening their research focus on the objects of the study.

The results may also assist researchers in identifying the most productive authors, publication sources, and countries on AI and sustainability in tourism entities. This phenomenon could enhance collaboration and fill in possible contextual gaps in the body of knowledge. For instance, the study also established that there is a limitation on studies specifically focusing on AI and sustainability in small and medium tourism enterprises (SMTEs), or small, micro, and medium tourism enterprises (SMMTEs), instead, what is available tends to generalise to the broader environment.

Hence, a more context-specific approach can be crucial because challenges affecting the tourism industry may vary depending on the size and location of the entity. Ultimately, this phenomenon could form part of the future direction, where more emphasis could be placed on focusing on more context-specific types of tourism entities.

This is reflective of the need to expand research in this direction, thereby increasing the scope of research interest. Based on the key overlay map, researchers can explore more combinations from the list of established keywords. The study focused on the Scopus database, of which future studies may consider other databases such as Web of Science, PubMed, and Google Scholar, or a combination of two databases to widen the search for scholarly publications. This might help researchers understand the nexus between the objects of the study better.

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