

Smart Tourism Research: Where Are We Going? A Science Map of the Field

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Abstract *This study aims to assess the trends in smart tourism systematically. From a bibliometric perspective, this study aims to investigate the research trends and map smart tourism worldwide visually. A bibliometric analysis was conducted on 176 relevant documents from the Scopus database. The research methodology includes co-word and co-citation analyses to assess the productivity, impact, and performance of countries, journals, authors, and research institutions. The study shows that the number of publications increases yearly, with the United Kingdom, Spain, China, and South Korea emerging as the top contributors. Keyword analysis identified four prominent research themes, characterized by 32 keywords with a least six occurrences. The clusters are (1)-ST destination management and tourist behaviour in the digital age; (2)-ST and sustainability in rural and heritage destinations; (3)-The impact of digital technology and digitalization on the tourism industry during and after the pandemic; (4)-ST and digital transformation in experience and sustainable development. Co-citation analysis of cited authors yielded a network of three clusters: Technology and Information Systems in ST, User Interaction and ST Experience, ST Development, and Digital Technology Application. The study's limitations include focusing only on the Scopus database without incorporating systematic review and content analysis. However, the authors believe that the findings capture the overall intellectual framework of the study because of the selection criteria used to determine which databases to analyze. The findings indicate that smart tourism research is still at a developmental stage, and notable knowledge gaps persist. This study aims to advance scholarly understanding and provide practical implications for stakeholders.*

Keywords: Smart Tourism, E-Tourism, Bibliometric Analysis, Science Map

INTRODUCTION

Tourism is now recognized as one of the most significant economic sectors, exerting direct and indirect impacts on society, contributing positively to spatial development at national, regional, and municipal levels, and promoting sustainability (Allawi, 2022). One of the modern trends in achieving sustainability in tourism is smart tourism (ST). ST can potentially create qualitative and quantitative transformation in local communities, from the economy, society, and environment to information and communication technology and cultural heritage. ST is the integration of advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), and big data into tourism activities, which has revolutionized the way destinations are managed, services are provided, and experiences are personalized for

tourists (Buhalis & Amaranggana, 2015). The expansion of this concept, which encompasses smart destinations, digital infrastructure, and improved interactions between tourists and service providers, has attracted substantial academic interest (Gretzel et al., 2015).

The swift emergence of ST has generated extensive academic interest, attracting researchers from diverse disciplines to examine its impact on various aspects, including destination management, visitor satisfaction, and economic sustainability. Over the past decade, the field has experienced a notable increase in research focused on topics such as smart cities, smart destinations, the role of information technology in tourism, and the integration of smart systems into tourism operations (Boes et al., 2016; Buhalis, 2020). These studies have examined the diverse applications of technology in optimizing travel processes,

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improving decision-making, and delivering real-time, data-driven services to travellers and service providers (Gretzel et al., 2015; Strickland & Ratten, 2024).

While numerous studies have contributed to ST, several critical gaps remain underexplored. Notably, the fragmentation of research topics and frameworks poses challenges for defining the developmental trajectory of ST. Furthermore, the disparity in smart technology adoption across various destination types and regions remains insufficiently examined, raising questions regarding the effectiveness and adaptability of smart technology solutions within diverse tourism contexts. Additionally, ST's social and cultural impacts, particularly regarding how different user groups interact with technology and how to design more inclusive and accessible solutions, have yet to be comprehensively addressed.

Consequently, this study seeks to answer the following research questions:

RQ1: What are the trends and research topics of ST over time?

RQ2: Who are the main contributors to ST in organizations, countries, and authors?

RQ3: What is the conceptual, social, and intellectual structure of ST publications?

To answer these questions, the study conducted a bibliometric analysis for Scopus scientific publications using bibliometric indices through VOSviewer software (Van Eck, Nees Jan Waltman, 2007). This approach will enable us to identify key research themes, influential authors, and key trends that have emerged over time. We will also assess the connections between different research groups, elucidating how different streams of knowledge interact and influence each other. In addition to mapping the current state of ST research, this paper also aims to provide insights into current trends in ST research and future directions for the field. This study will make a significant theoretical contribution to the ST literature, helping to link future research efforts to the needs and challenges of a rapidly changing tourism landscape.

METHODOLOGY

The screening and selection process described above followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, a well-established approach to ensuring transparency and rigour in systematic reviews (Moher et al., 2009; Yasmin et al., 2025). The PRISMA flow diagram outlines the process of identifying, screening, qualifying, and including documents in the final dataset (Fig. 1).

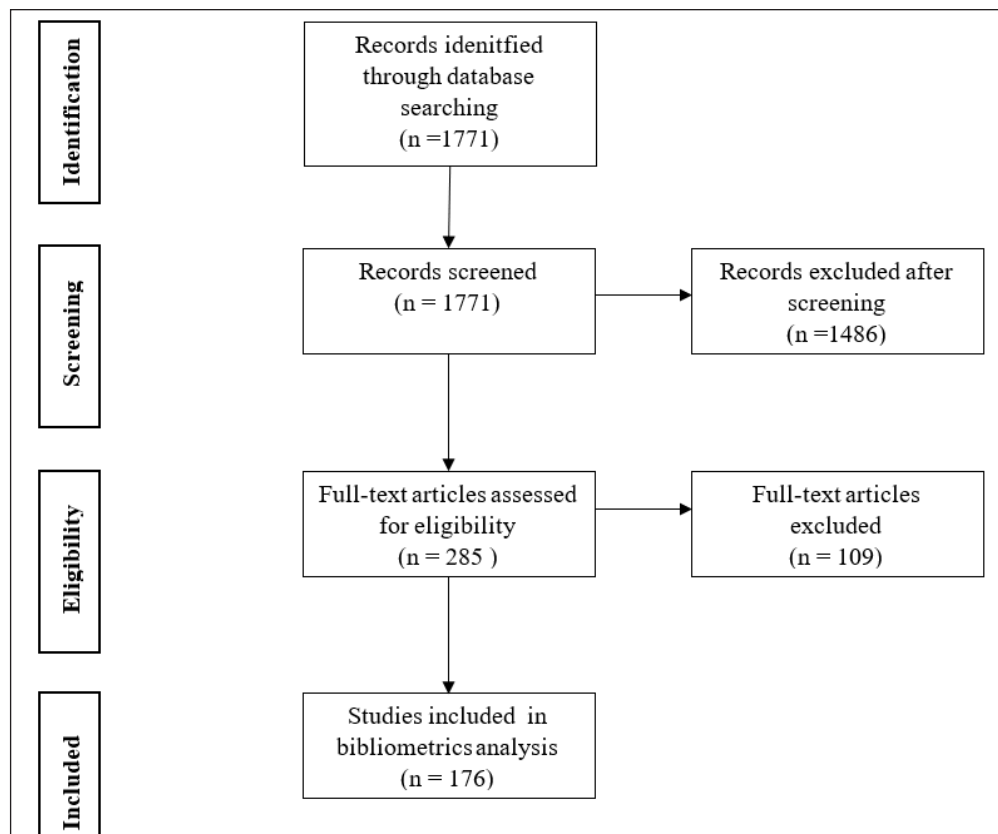


Fig. 1: PRISMA Flow Diagram

Data for this study were systematically collected from Scopus, one of the most comprehensive academic databases, to construct a detailed mapping of ST. The data collection occurred on August 30, 2024, and focused on identifying literature pertinent to ST. Scopus was selected due to its extensive coverage of peer-reviewed publications and multidisciplinary scope, which is essential for encompassing the broad range of ST research, including technology, management, and social sciences (Le-Dinh et al., 2025). Scopus is recognized as the largest repository of diverse peer-reviewed scholarly literature, encompassing journal articles, conference proceedings, books, and review articles (Martín-Martín et al., 2018). Its widespread use among scholars has also established it as a preferred database for conducting bibliometric analyses in numerous prior research studies (Liu et al., 2022; Mulet-Forteza et al., 2018).

The first step in our data collection process involved defining the exact search query. Based on previous research and conceptual frameworks in the field, we formulated the following query to capture relevant documents: “Smart tourism” OR “Digital tourism” OR “Electronic tourism” (Madeira et al., 2023). The initial search using the above query yielded a total of 1771 documents. These documents spanned a wide range of disciplines, reflecting the interdisciplinary nature of ST research. To narrow the scope and ensure that our analysis focused on the areas most relevant to the intersection of tourism and technology, we applied the following filters:

- *Subject Area Filter:* We focus on documents classified into the following areas: ‘Social Sciences’; ‘Business, Management and Accounting’; ‘Decision Sciences’; ‘Economics, Econometrics, and Finance’ and ‘Psychology’. After this step, this filtering reduced the total number of documents to 1101. These topic areas were selected to ensure that the dataset reflects ST’s technological aspects and impact on business operations, decision-making processes, and human behaviour.
- *Document Type Filter:* We limited our selection to articles to refine the dataset, excluding book chapters and conference papers. Articles were selected because they typically undergo a more rigorous peer review process, ensuring the quality and reliability of the information. This step reduced the dataset to 621 documents.
- *Language Filter:* Only documents published in English were selected, as English is the dominant language of international academic discourse, especially in tourism and technology research. There exists a divide among scholars regarding the significance of language criteria in influencing the efficiency of bibliometric analysis.

Some argue that the language factor is paramount, advocating for a strict focus on articles published exclusively in English. In contrast, others contend that non-English articles exert minimal impact on bibliometric analysis studies, as their contributions are relatively minor in various bibliometric analysis facets, considering their inclusion in the overall dataset (van Raan, 2005). This filter reduced the dataset to 594 documents.

- *Access Type Filter:* We also applied a filter to include only open-access documents, ensuring that the articles used in this analysis would be freely available to researchers. This step reduced the number of articles to 285.

The next stage is keyword refinement, which involves refining the keyword selection to focus on specific documents relevant to ST. The study employed a stepwise filtering procedure to refine the initial search results into the final dataset. The retrieval was conducted using topic terms related to smart tourism, and the results were restricted to English open-access journal articles within the subject areas of business, social sciences, decision sciences, economics, and psychology. The final search statement is presented as follows: TITLE-ABS-KEY (“smart tourism” OR “digital tourism” OR “electronic tourism”) AND (LIMIT-TO (SUBJAREA, “BUSI”) OR LIMIT-TO (SUBJAREA, “SOCI”) OR LIMIT-TO (SUBJAREA, “DECI”) OR LIMIT-TO (SUBJAREA, “ECON”) OR LIMIT-TO (SUBJAREA, “PSYC”)) AND (LIMIT-TO (DOCTYPE, “ar”)) AND (LIMIT-TO (LANGUAGE, “English”)) AND (LIMIT-TO (OA, “all”)).

This keyword refinement process resulted in 182 documents, with six documents missing the abstract and keyword fields after screening. This resulted in a final dataset of 176 documents that met specific criteria for relevance to ST. By focusing on these keywords, we ensured that the selected documents provided a comprehensive overview of various dimensions of ST research, including smart cities, smart destinations, and technology applications in tourism.

With the final dataset of 176 documents, we performed a bibliometric analysis of singular and plural, abbreviated and full keywords, such as smart cities/ smart city, smart destinations/ smart destination, ST destinations/ ST destination. We then conducted a bibliometric analysis using tools such as VOSviewer to map co-citation networks and identify key research clusters in ST (Van Eck & Waltman, 2017). These tools play an essential role in visualizing the intellectual structure of the field, revealing key authors, frequently cited articles, and topic clusters. Co-citation analysis allows us to identify the most influential studies and understand the relationships between different research

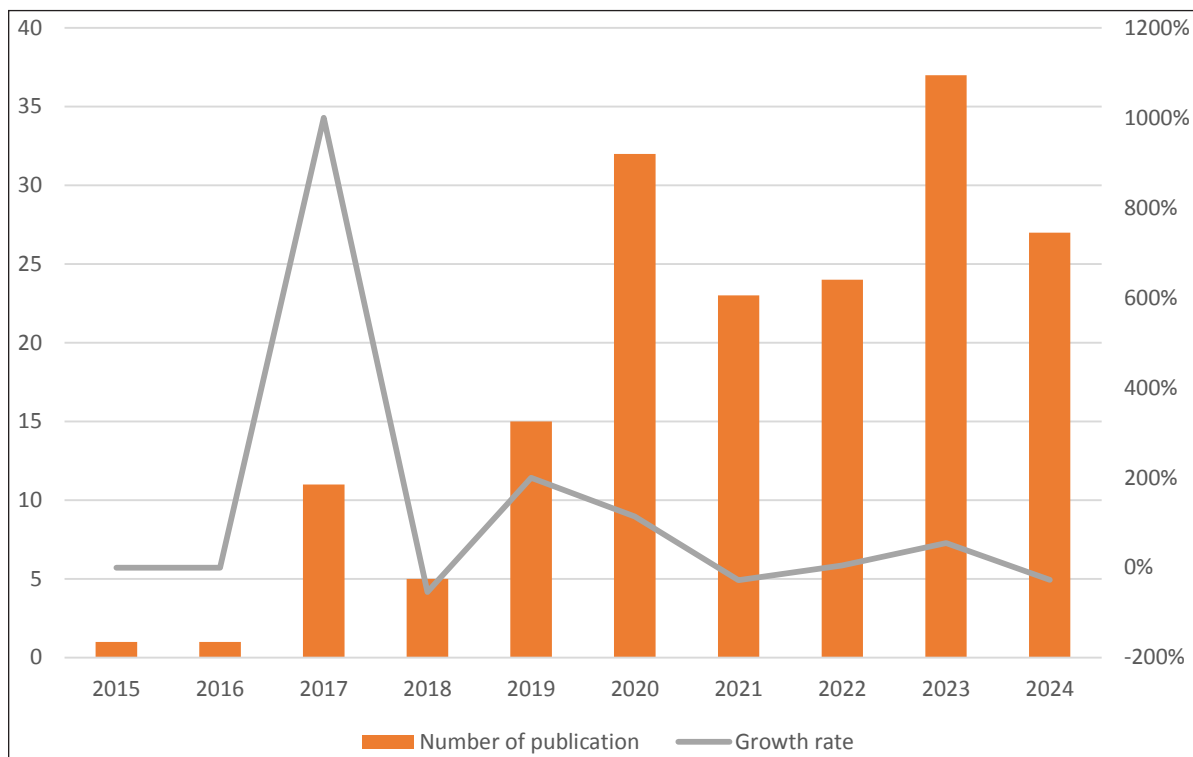
streams in ST. In addition to co-citation analysis, keywords were co-occurrences to identify emerging topics and trends in ST research. By examining the frequency and co-occurrence of keywords, we can track the evolution of research topics and predict future directions in the field (Boyack & Klavans, 2010).

RESULTS

Annual Publication Growth and Country Distribution

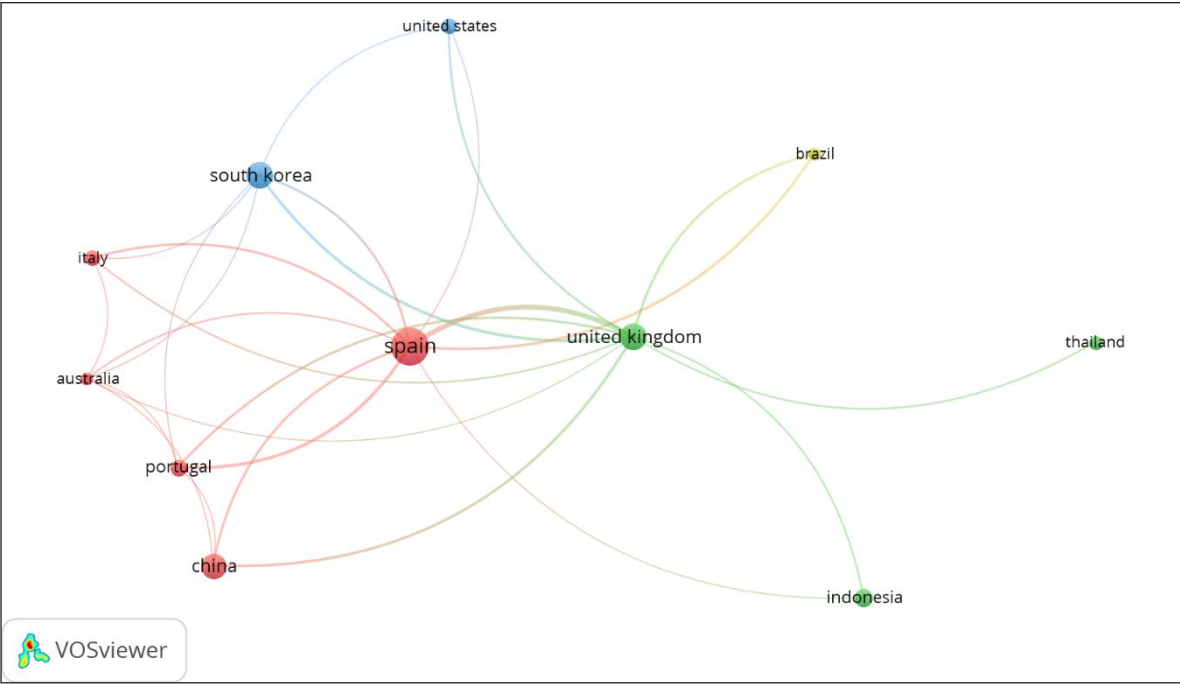
The initial studies on ST were published in 2015, with no increase observed between 2015 and 2016 as publication counts remained at one, indicating a gradual initial interest in the ST field. However, a notable increase occurred from 2016 to 2017, with publications rising sharply from one to eleven, reflecting growing scholarly engagement with ST topics. Following this peak, a reduction to five publications in 2018 suggests a period of recalibration within the field.

From 2019 onwards, the number of publications grew significantly, rising from 15 in 2019 to 32 in 2020. This increase likely reflects an expanded research capacity and heightened demand for ST research, driven by emerging trends and the pressing need for smart solutions in response to the COVID-19 pandemic. The pandemic's disruption of the global tourism sector, marked by border closures, travel restrictions, and a sharp decline in tourism, underscored the urgency of applying smart technologies to enhance safety, manage tourism flows, and support post-pandemic recovery efforts. While publication output declined to 23 articles in 2021, a slight recovery was observed in subsequent years, with 24 publications in 2022 and a peak of 37 publications in 2023. As of 2024, publication numbers have slightly decreased to 27 due to data collection being limited to the end of August, yet they remain elevated compared to earlier years (Fig. 2). The expanding research base on ST contributes to multiple fields, including cultural, social, economic, and technological dimensions, underscoring the field's interdisciplinary impact.



Source: Scopus data analysis results, August 2024.

Fig. 2: Number of Publications from 2015 to 2024



Source: Scopus data analysis results, August 2024.

Fig. 3: Scientific Output Distribution of Countries

Fig. 3 illustrates the cooperative relationships between countries, represented by connecting lines. The circles (nodes) signify individual countries, while the lines (edges) indicate levels of linkage or collaboration. Colour variations among the lines reflect the degree of proximity or clustering of countries with close academic ties. The analysis reveals that 11 countries are particularly active in publishing ST-related articles, each with at least five publications. The map highlights international cooperation, with darker colours denoting a higher frequency of articles. Spain leads in ST publications, with a total of 37 articles, followed by prominent contributors, including the United Kingdom (20 publications), South Korea (19 publications), and China (18 publications). Notably, the United Kingdom exhibits

the highest link strength, with 1,508 citations and a total link strength of 46, indicating substantial influence and connectivity within the ST research network.

Network of Authors and Journals

Table 1 provides details of the most influential authors in the ST field, based on their publications. The table presents a list of leading research articles in the field of ST, ranked by citation count, reflecting each article’s impact based on the level of scholarly engagement. These articles investigate various dimensions of ST, encompassing a range of topics, including technology, smart cities, user experience, and sustainable development.

Table 1: Top 10 Authors of Articles with the Highest Number of Citations

Rank	First Author	Titles	Citations
1	Buhalis, Dimitrios	‘Buhalis, D. (2019). Technology in tourism-from information communication technologies to eTourism and smart tourism towards ambient intelligence tourism: a perspective article’. <i>Tourism Review</i> , 75(1), 267–272. doi:10.1108/tr-06-2019-0258’.	460
2	Khan, M. Sajid	‘Khan, M., Woo, M., Nam, K., & Chathoth, P. (2017). Smart City and Smart Tourism: A Case of Dubai. <i>Sustainability</i> , 9(12), 2279. doi:10.3390/su9122279’.	159
3	Stankov, Uglješa	‘Stankov, U., & Gretzel, U. (2020). Tourism 4.0 technologies and tourist experiences: a human-centered design perspective. <i>Information Technology & Tourism</i> . doi:10.1007/s40558-020-00186-y’.	150
4	Skinner, Heather	‘Skinner, H., Sarpong, D., & White, G. R. T. (2018). Meeting the needs of the Millennials and Generation Z: gamification in tourism through geocaching. <i>Journal of Tourism Futures</i> , 4(1), 93–104. doi:10.1108/jtf-12-2017-0060’.	125

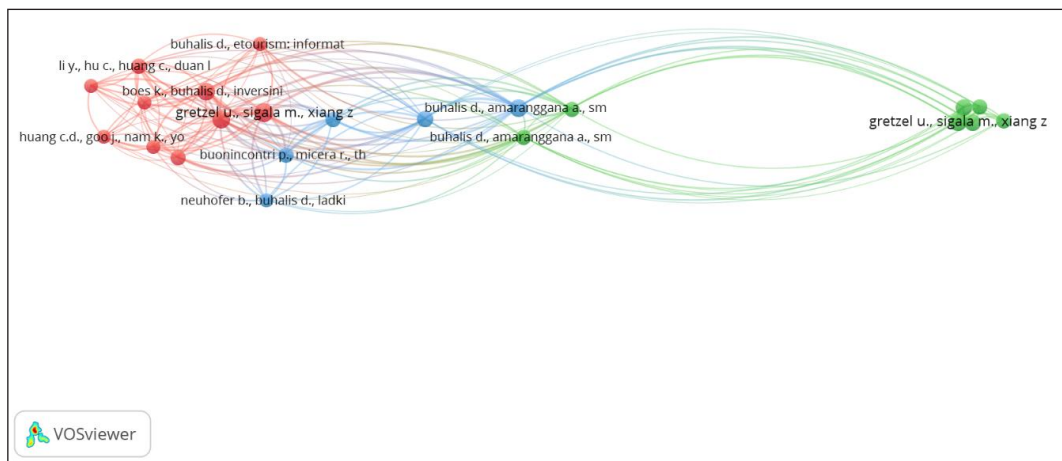
minimum of three documents, with 11 journals identified as the most active. Within this network, *Tourism Review* emerges as a key journal, showing strong connections to other influential publications such as *Tourism Management Perspective*, *Current Issues in Tourism*, and *Cities*, highlighting its central role in synthesizing and linking tourism research.

On the right side of the map, *Sustainability (Switzerland)* and the *Journal of Tourism Futures* are interconnected, with both linked to *Tourism Review*. This pattern suggests that research on sustainability within tourism and studies on the industry's future are crucial and highly integrated themes. The distinct colors of connecting lines denote clusters of related research areas, revealing close associations among certain journals

and topics. For instance, the left cluster containing *Tourism Review* and *Tourism Management Perspective* is represented by a different color than the right cluster with *Sustainability (Switzerland)*, potentially indicating distinct focal areas within tourism research. Additionally, *Current Issues in Tourism* and *Cities* display strong interconnections, likely reflecting research intersections between urban management and tourism development within urban contexts.

Co-Citation Analysis

With 10,826 cited references, the authors chose 8 times as the minimum number of citations, resulting in 22 items and 3 clusters.



Source: Scopus data analysis results, August 2024.

Fig. 5: The Co-Citation of ST Research

Fig. 5 is a co-citation network generated using VOSviewer, which shows the degree of interconnection and citation among research on tourism, e-tourism, and information technology in tourism. The authors in this cluster have a high degree of interconnection, as shown by their many links, indicating that they often cite and reference each other in their research works.

Cluster 1 (red) is named “*Technology and Information Systems in ST*,” focuses on research on e-tourism and the application of information and communication technology in the tourism industry, especially related to information systems and digital connections. Cluster 1 has the primary authors Buhalis D., Boes K., Huang C., Li Y., Goo J., and Nam K. This cluster includes authors with many studies related to e-tourism, information and communication in tourism, and technology applications in the industry. The most prominent author is Buhalis D., a scholar with many research works on e-tourism, often cited in studies related to the development and application of digital technology in tourism. The studies

of Boes K. and Huang C. also contribute significantly to the topics associated with ST experience and technology application, showing the substantial transformation of the tourism industry under the impact of digitalization.

Cluster 2 (blue), titled “*User Interaction and ST Experience*,” centers on research examining user engagement with technology and digital elements in tourism, particularly in smart tourism (ST) experiences and the influence of technology on users. The primary contributors to this cluster include Gretzel U., Sigala M., and Xiang Z. Researchers here concentrate on e-tourism and ST, emphasizing user interaction with technological and information systems in tourism contexts. Gretzel U. stands out as a leading figure in e-tourism, frequently cited alongside Sigala M. and Xiang Z. in studies investigating the technological impact on tourism experiences. The close academic relationship among these authors is highlighted by dense connections in the diagram, indicating their consistent collaboration and shared research interests.

Cluster 3 (green), titled “*ST Development and Digital Technology Application*,” focuses on the development of ST models and the application of technology in tourism management and organization, with an emphasis on collaborative efforts to create advanced technological solutions. This cluster is primarily contributed to by Buhalis D. and Amaranggana A., who have extensively studied ST development strategies. The strong linkage between Buhalis D. and Amaranggana A., evidenced by multiple connecting lines in the diagram, reflects a shared focus on advancing technology-driven solutions to foster a more intelligent tourism industry.

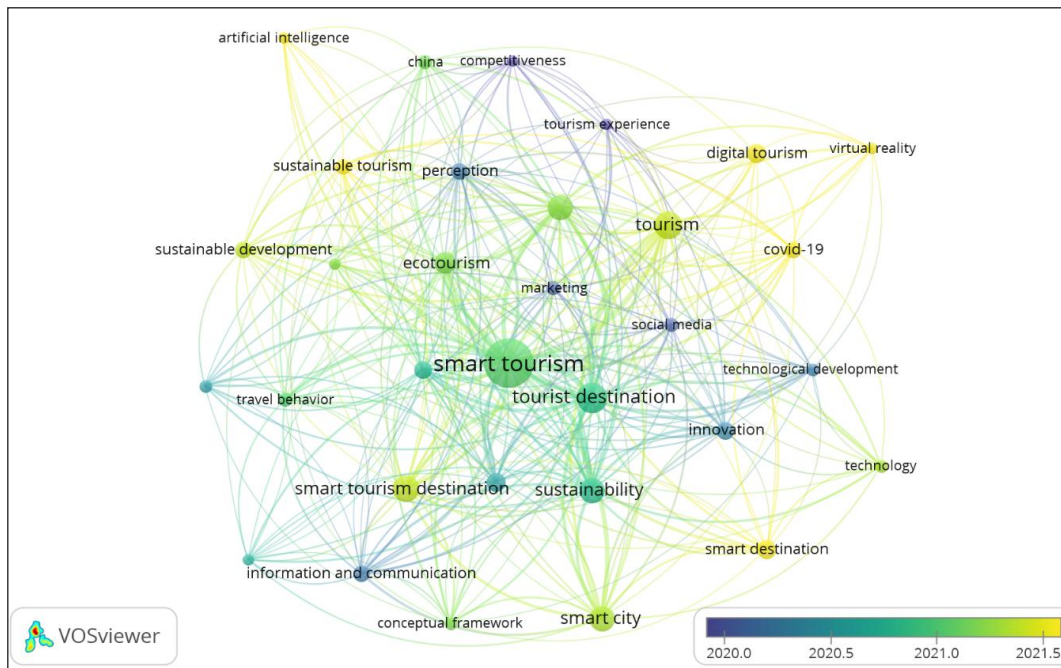
This co-citation graph not only helps identify three main author clusters in the field of e-tourism and ST but also shows the solid academic connections between the authors, especially Buhalis D., Gretzel U., and Sigala M. These authors play a crucial role in guiding and developing research on smart technology in tourism, contributing to improving service quality and tourist experience in the digital age.

Co-Occurrence Keyword Analysis

Co-occurrence keyword analysis is a bibliometric method used to identify and assess relationships between keywords that appear simultaneously within research documents. This

technique enables the identification of prevalent topics and their interconnections within a particular research domain by analyzing the frequency and co-occurrence of keywords within the same document (Pritchard, 1969). The method operates under the assumption that when two or more keywords frequently appear together across a substantial number of documents, they are likely closely related in content or pertain to a specific research theme. By employing keyword co-occurrence analysis, researchers can discern key topics within the field, understand the relationships among these topics, uncover emerging research trends and potential areas for investigation, and assess the evolution and transformation of the research field over time.

Out of the 176 documents analyzed, 32 met the citation threshold of minimum 6 citations, resulting in the formation of four clusters. Fig. 6 illustrates the keywords associated with the ST research and their interrelationships over time, specifically from 2020 to 2021. Central keywords, including “smart tourism,” “tourist destination,” “sustainability,” and “technology,” are prominently positioned and exhibit strong connections with surrounding keywords. The colors in the chart represent the time frame during which these keywords frequently appear in research, with shades ranging from dark blue (2020) to light yellow (mid-2021), thus indicating the progression and shifts in ST research focus over the analyzed period.



Source: Scopus data analysis results, August 2024.

Fig. 6: The Trend of Keywords Over Time

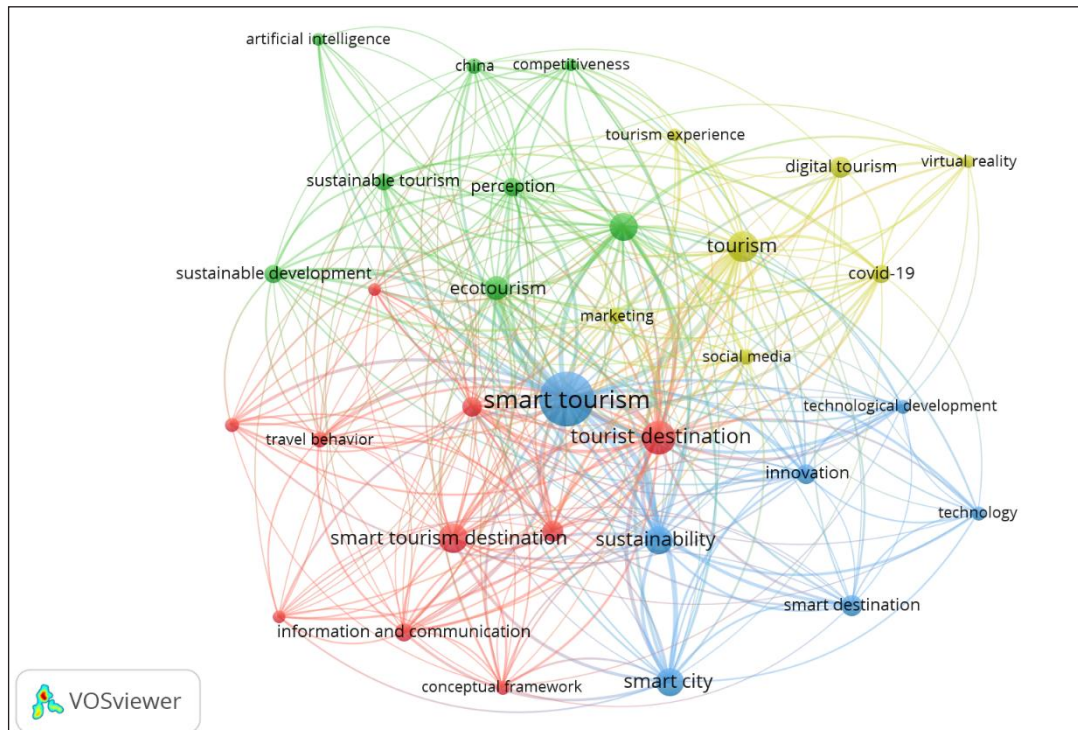
Keywords such as “information and communication,” “tourist behavior,” and “tourism market” appeared earlier in the research timeline (dark blue), signifying foundational

aspects investigated predominantly in the initial stages of the research period, particularly before and during the pandemic. In contrast, keywords like “virtual reality,” “COVID-19,”

“artificial intelligence,” and “sustainable tourism” are emerging terms (light yellow), showing increased prominence beginning in 2021. ST is the central keyword, connecting with factors such as “tourist destination,” “sustainability,” “technology,” and “smart city,” showing the close connection between technology and sustainability factors in the tourism sector. The prominence of “technology” and “virtual reality” highlights the growth of new digital innovations in ST, particularly amid the pandemic, which has accelerated the

demand for digital solutions. Additionally, “sustainability” and “sustainable tourism” are interconnected with “tourism development” and “quality of life,” underscoring the critical role of sustainable development within ST strategies.

Fig. 7 distinguishes different keyword clusters by color, with each cluster representing a group of related research topics in the ST field. Cluster 1 is the most productive cluster, with 10 publications, followed by Cluster 2 with 8 publications. Clusters 3 and 4 each have 7 publications.



Source: Scopus data analysis results, August 2024.

Fig. 7: The Co-Occurrence Network of ST Research

Cluster 1 (red) consists of 10 keywords, focusing on important aspects related to tourist destinations, tourist behavior, and the role of technology in ST management. Keywords such as “tourist destination”, “ST destination”, “information and communication technology”, “tourism management”, “tourist behavior”, and “travel behavior” provide a comprehensive picture of how the modern tourism industry is transforming through technology and how tourists interact with tourist destinations. Therefore, we have named this cluster “*ST destination management and tourist behavior in the digital age*.” This name accurately reflects the content of the keywords in the cluster, focusing on the combination of tourism management, tourist behavior, and the role of information technology in improving the experience and managing DT destinations.

The research of this cluster revolves around three contents: ST ecosystems, tourist experiences and behaviors, and

ST destination management. The first content refers to the concept of ST ecosystems, examining how advanced technologies such as IoT, AI, big data analytics, and geographic systems play a role in ST development (Aliyah et al., 2023), (Popova et al., 2023). The main components of the ecosystem include tourists, technology, stakeholders, and the social environment. Research within this group has demonstrated how big data analytics and IoT technologies can facilitate risk management and optimize the travel experience by analyzing and processing data from diverse sources, thereby enhancing decision-making capabilities. Despite the great potential of big data and IoT, many studies have found that these systems still struggle to manage complex and heterogeneous data (Solazzo et al., 2022). Ecosystem Theory is the theory mentioned in the first content (Sedarati et al., 2022). The second content of this cluster is about tourist experience and behavior. Most of the research focuses on understanding tourist behavior,

including how they respond to technological elements in ST destinations, loyalty, and word-of-mouth intentions (Nieves-Pavón et al., 2024). The theories referred to in this content are theory of e-consumption behavior and the management theory (Hasan et al., 2024), (Nieves-Pavón et al., 2024). The variables used in many studies are emotions, tourist behavior, technology, and risk, which are important factors in building loyalty and word-of-mouth intention, technology friendliness, level of personalization, and convenience of information play an important role in shaping tourists' perception (Mendes Filho et al., 2022). The third content of this cluster is ST destination management, planning, managing tourist emotions, optimizing experiences, and promoting sustainability. Studies also found that the level of access to ST technologies is uneven across destinations, leading to differences in the level of effectiveness in tourism management and development (Wang et al., 2020; Radojević et al., 2023).

Cluster 2 (green) consists of 8 keywords, with the main keywords such as tourism development, ecotourism, perception, sustainable development, and sustainable tourism reflecting the interest in sustainable tourism development, especially in ecotourism. These keywords show the focus on important aspects of tourism development not only from the economic perspective but also from the environmental and social perspective. Therefore, we named cluster 2 "*ST and sustainability in rural and heritage destinations*".

Studies in this cluster focus on the relationship between ST technology and sustainability, especially in rural areas and cultural heritage destinations. Notable commonalities include the exploitation of advanced technologies such as AI, IoT, and big data to enhance tourism experiences, preserve cultural heritage, and manage resources sustainably. Studies highlight how technology can contribute to heritage conservation and local economic development (Moise et al., 2023), (Balakrishnan et al., 2023), analyze the challenges and opportunities in applying smart technology to balance environmental conservation and ecotourism development (Chanda et al., 2023; Vu et al., 2025). The findings from studies in this cluster demonstrate the enormous potential of technology to support sustainable development, from improving resource management to creating personalized tourism experiences. However, some studies indicate that not all smart destinations focus on technology but can also build on existing cultural and social factors (Johnson, 2023). In addition, challenges such as difficulties in data management and uneven access to technology in rural areas still exist. The underlying theories used in this cluster include path dependence theory to explain the development process based on the historical context of each locality (Johnson, 2023), and theories of sustainability and the metaverse to measure the effectiveness of sustainable development through technology (Suanpang et al., 2022) the existing

metaverse platform demonstrated that the technology is still difficult to develop, as the service provider did not disclose the internal mechanisms to developers, and it was a closed system, which could not use or share the user's data across platforms. The aim of this paper was to design and develop an open metaverse platform called the "extensible metaverse", which would allow new developers to independently develop the capabilities of the metaverse system. The acquisition of this new technology was conducted through requirements analysis, then the analysis and design of the new system architecture, followed by the implementation, and the evaluation of the system by the users. The results found that the extended metaverse was divided into three tiers that created labels, characters, and virtual objects. Furthermore, the linking tier combined the 3D elements, and the deployment tier compiled the results of the link to use all three parts by using the Blender program, Godot Engine, and PHP + WebGL as their respective key mechanisms. This system was tested in Suphan Buri province, Thailand, which was evaluated by 428 users. The results of the metaverse satisfaction, created tourism experience, and overall satisfaction of the variation of the satisfaction of using the metaverse were 86.0%, 79.7%, and 92.9%, respectively. The relative Chi-square (χ^2/df). The main variables used are sustainability, tourist behavior, and technology access. Sustainability is an important variable in most studies, aiming to measure the sustainability of destinations and the impact of technological solutions. Studies also show that the combination of AI and IoT can provide innovative solutions for sustainable tourism development (Suanpang & Pothipassa, 2024) system architecture analysis and design, implementation, and user evaluation. The results revealed that the synergistic combination of these technologies was organized into three tiers. The system provides information, including place names, images, descriptive text, and an audio option for users to listen to the information, supporting tourists with disabilities. Employing advanced AI algorithms alongside NLP, developed systems capable of generating predictive analytics, personalized recommendations, and conducting real-time, multilingual communication with tourists. This system was implemented and evaluated in Suphan Buri and Ayutthaya, UNESCO World Heritage sites in Thailand, with 416 users participating. The results showed that system satisfaction was influenced by (1, highlights the potential of the Metaverse to improve the ST experience (Suanpang et al., 2022) the existing metaverse platform demonstrated that the technology is still difficult to develop, as the service provider did not disclose the internal mechanisms to developers, and it was a closed system, which could not use or share the user's data across platforms. The aim of this paper was to design and develop an open metaverse platform called the "extensible metaverse", which would allow new developers to independently develop the capabilities of the metaverse system. The acquisition of this new technology

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Cluster 3 (blue) includes seven keywords: tourism, digital tourism, COVID-19, marketing, social media, tourism experience, and virtual reality. It focuses on the development of digital tourism and changes in the tourism industry under the impact of COVID-19. Therefore, cluster 3 is named “*the impact of digital technology and digitalization on the tourism industry during and after the pandemic.*”

The studies in this cluster focus on the relationship between digital technology and the tourism industry, especially the digital revolution that profoundly impacts the tourism and hospitality industries. Overall, the studies in this cluster aim to explore different aspects of digital tourism, from analyzing research and development trends over the past three decades to the impact of the COVID-19 pandemic on cultural tourism (Wallace et al., 2023). The study highlights how technologies such as social media, virtual reality (VR), and big data analytics tools have become important factors in promoting tourism development. These studies also show the change in tourist behaviour, as they increasingly rely on digital platforms to make purchasing and experience decisions (Lee, 2022). Some studies delve into specific applications of technology, such as using the LeNet-5 algorithm to classify tourist objects or mining data from platforms like Airbnb to understand urban tourism spaces better (Wijaya et al., 2023; Stors & Baltes, 2018; Minca & Roelofsen, 2021). The authors also focus on the impact of technology on sustainable tourism, especially the role of social media in restoring tourism after the pandemic. In addition, studies analyze how factors such as travel anxiety affect digital technology usage behaviour, showing the complexity of adapting these technologies to meet the diverse needs of tourists. In summary, the common feature of studies in this cluster is that they reflect fundamental changes in the tourism industry due to the impact of digitalization while providing a comprehensive view of how technology is reshaping the travel experience and tourism economic development globally.

Cluster 4 (yellow) includes seven keywords: ST, sustainability, smart city, smart destination, innovation, technology, and technological development. Cluster 4 can be named “*ST and digital transformation in experience and sustainable development.*” This name reflects the focus of the studies on using digital technology to enhance the tourism experience, personalize services, promote sustainability, and improve tourism accessibility for all customers.

The studies in this cluster revolve around the theme of ST and the integration of modern technology to enhance the tourism experience. In general, the studies focus on various aspects of ST, including the use of new technologies such as the Internet of Behaviors, AI, blockchain, mobile technology, and social networks to improve the convenience, experience, and sustainability of tourism (Kim & Kim, 2017; Kwok, 2023; Puri et al., 2023). One highlight is the focus on the role of technology in optimizing services and enhancing the personalization of the traveller experience. Studies have addressed the use of AI to develop smart travel applications, such as recommendation systems and traveller service applications, which help personalize services and increase satisfaction. In addition, technologies such as blockchain have also been studied to improve transparency and safety in the tourism industry (Bustard et al., 2019). At the same time, studies also emphasize the importance of applying technology to sustainable development, such as ecotourism plans and data-based tourism management methods to conserve natural resources and minimize negative environmental impacts (Dabeedooal et al., 2019), (Romão & Neuts, 2017). In addition, many studies have shown how technology can improve travel accessibility for people with disabilities and the elderly through the use of user-friendly and easy-to-use technologies. Research also focuses on developing experience-based tourism, using technology to optimize cultural and heritage exploration. The application of AR and VR technology in museums and cultural destinations helps attract tourists and creates rich interactive experiences, enhancing attachment to the place (Naramski, 2020), (Samora-Arvela et al., 2020).

DISCUSSION AND CONCLUSION

Theoretical and Practical Implications

This research offers several theoretical and practical contributions to the ST. First, the upward trend in publication output over the years, despite notable fluctuations, reflects the field’s dynamic development. Significant shifts in research activity or publication capacity were observed in 2017 and 2020, while temporary declines in certain years may be attributed to strategic shifts in research focus or external factors, such as economic or social conditions.

The evolution of ST-related publications is closely linked to the COVID-19 pandemic, which intensified the demand for digital transformation and technology adoption in the tourism sector. In this context, ST has emerged as a crucial solution to address challenges within the global tourism industry, establishing a foundation for a more sustainable and technologically advanced future.

Second, the co-citation network analysis, visualized using VOSviewer, underscores the intricate relationships among technology, travel behavior, and sustainable management within ST research. Cluster 1, represented by influential authors such as Buhalis D. et al., concentrates on “Information Systems and Technology in ST,” establishing a foundation for the integration of information technology in e-tourism, particularly through systems supporting tourism service and management. Cluster 2, led by scholars such as Gretzel U., Sigala M., and Xiang Z., focuses on user interaction and experience, investigating how travelers engage with ST technologies to create personalized and comprehensive travel experiences. Cluster 3, involving researchers such as Amaranggana A. and Buhalis D., emphasizes ST development through digital applications, reflecting the evolving trend towards not only implementing technology but also developing sustainable and efficient solutions. The strong interconnections among these authors indicate a high level of consensus in advancing theoretical and practical frameworks that support the growth of the ST field, aligning with the demands of the digital age.

Third, the keyword co-occurrence analysis revealed multi-dimensional perspectives on ST and sustainable tourism development facilitated by advanced technologies. Cluster 1, the most prolific cluster, focused on smart destination management and tourist behavior in the digital era, emphasizing the integration of user experience and the role of technology in enhancing tourism experiences and managing destinations. Cluster 2 concentrated on ecotourism and sustainability, particularly within heritage and rural regions, where technology is leveraged to preserve cultural heritage and promote local economic development. In contrast, cluster 3 examined the effects of digitalization on tourism, especially during the COVID-19 period, highlighting shifts in tourist behavior and increased reliance on digital platforms, underscoring the critical role of technology in tourism recovery efforts. Finally, cluster 4 emphasized the role of technology in enriching travel experiences and promoting sustainability, with a focus on cutting-edge tools such as AI, blockchain, and social media to enhance service accessibility and personalization.

Both the co-citation and keyword co-occurrence analyses reveal consistent trends and interconnections among authors and topics within ST and sustainable tourism research. While each method approaches the topic from a distinct perspective, they complement one another, collectively

providing a comprehensive view of the research landscape. Both analyses underscore the significance of sustainability, particularly in ecotourism and cultural heritage conservation, and acknowledge shifts in tourist behavior in response to technological advancements and the impact of COVID-19. Additionally, the prominent role of technologies such as AI, the IoT, and big data in transforming the tourism industry is highlighted in both analyses, underscoring their importance in advancing ST and sustainable tourism practices.

Limitations and Future Research

All research has limitations, and this study is no exception. Several limitations should be acknowledged to inform future research directions. Firstly, reliance on Scopus as the sole database may have excluded relevant studies indexed in other sources, such as Web of Science or Google Scholar. Additionally, the focus on English-language and open-access literature may introduce a bias towards specific geographic regions, potentially overlooking significant contributions in non-English publications.

The articles within this research database have made substantial progress in applying technology to ST, enhancing customer experience, and destination management. Nevertheless, limitations persist in both the research scope and practical applications, particularly within emerging markets. Many articles remain focused on theoretical aspects and lack large-scale practical implementations. The adoption of new technologies is hindered by limited resources and insufficient technological infrastructure at many destinations. Additionally, certain studies do not fully account for the cultural and psychological factors influencing user interactions with technology, nor have they examined in depth the disparities in technology access among different customer groups. Research on technology applications in tourism remains concentrated on developed countries and major destinations, with limited focus on emerging markets. Furthermore, regional and national differences in technology acceptance have not been comprehensively addressed.

To advance the field, future research should prioritize the development of practical ICT application models for tourism and investigate factors that facilitate or impede technology adoption in emerging markets and smart destinations. Diverse studies on user interactions with technology in tourism are also needed, particularly concerning emerging technologies such as virtual reality (VR) and the metaverse. Additionally, further exploration of technology's long-term impact on tourism consumption behavior, expanded research on ST technology application in developing countries, and more in-depth studies on smart policies and management models promoting sustainable tourism development are recommended.

Despite its limitations, the methodology and findings in this study offer a comprehensive and systematic approach to mapping the research landscape of ST, yielding valuable insights into the current state of the field and potential future directions.

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