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Tourist Tracking Techniques and Their Role in Destination Management: A Bibliometric Study, 2007–2023

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Abstract: The tourism industry has recently undergone a significant evolution because of the implementation of Information and Communication Technologies (ICT). These changes have raised new conceptions of destinations, thus giving rise to smart destinations. In this context, digital tracking of tourists has become of great interest. This article aims to analyze the research landscape on tourist tracking through a bibliometric study, which allows the evaluation of the performance of publications, recognition of the prominent SciVal topics, analysis of the evolution of the techniques, and recognition of their use as a tool that contributes to the development of smart destinations. Unlike prior studies in this area, in addition to the performance analysis of publications, this paper focuses only on empirical studies on tourist tracking, identifies the prominent SciVal topics, and analyzes the linkage thereof with the Sustainable Development Goals (SDGs). The bibliometric study was carried out based on articles on tourist tracking extracted from the Scopus database and published between 2007 and 2023. This research is mainly quantitative, based on research performance analysis (journals, authors, institutions, and countries) and science mapping (citation analysis, co-word analysis, co-authorship analysis). Results show the quality of the publications made in the 2007–2023 period and indicate that the most used techniques have been GPS devices, social media, and app-based GPS/GNSS. In addition, it was found that the evolution of the techniques occurred at the same time as the development of ICT and that the prominent SciVal topic that covers the largest number of publications is associated with destination management. It is concluded that the application of tourist tracking techniques contributes to the transformation of destinations into smart destinations, as they provide useful relevant information to tourism market stakeholders for the development of strategies that improve decision-making and allow for the sustainable management of destinations.

Keywords: tourist tracking; big data; topic prominence; smart destinations; SDGs

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1. Introduction

In recent years, the tourism industry has undergone a significant evolution because of the implementation of ICT [1]. Given the information-intensive nature of tourism and its strong reliance on ICTs, the concept of smart tourism has emerged to describe this current stage of tourism development [2]. Smart tourism is based on the ability of tourism businesses and destinations not only to collect large amounts of data, but also to store, process, analyze, and intelligently use big data to design operations, services, and business innovations in the tourism industry [2].

Destination Management Organizations (DMOs) currently face challenges such as defining destination boundaries, understanding tourists' needs and behavioral patterns, forecasting destination demand, delivering customized products and services, ensuring marketing effectiveness and competitiveness, and ensuring destination sustainability [3–6]. Considering the new digital era, big data analysis contributes to overcoming some of these challenges, as it allows an understanding of the behavior of tourists [4], thus managing

destinations appropriately. The benefits of using big data for statistical purposes lie in its efficiency, speed, completeness, and cost reduction [7].

Recently, a matter that has aroused great interest, associated with big data analysis, are tourist tracking techniques, which are used to digitally track people in time and space [8]. Data collected through these techniques allow forecasting tourist flows, knowing why certain places are visited, the timing of visits, and the profile of tourists visiting these places, to develop new tourism products, improve the on-site experience of tourists, target marketing budgets more effectively, and answer questions about carrying capacity, hotel allocation, transportation possibilities in a destination, and the orientation of tourists towards more sustainable options. These questions can be easily and reliably answered, compared to traditional survey methods [7–9].

Tourist tracking techniques provide information that allow the identification of problems at destinations and based on this knowledge, solution approaches. Some of these problems are: overcrowding at points of interest, even identifying in which time slot they occur [10,11]; the need for new transportation routes between points of interest [10]; the need for new tourist attractions; and the seasonality of attractions, points of interest, and itineraries [7].

Previous bibliometric studies on tourist tracking have focused on establishing which techniques are primarily used, presenting the evolution of the use thereof, together with the advantages and disadvantages of these techniques [12,13]. This paper, on the other hand, goes further, offering singularities that add value to the traditional bibliometric study, namely, the analysis of empirical studies only, the prominent SciVal topics, and the association of studies on tourist tracking with the Sustainable Development Goals (SDGs).

A bibliometric analysis, specifically of empirical studies on tourist tracking, provides different tools not only to tourism researchers for the planning of their studies, but also to DMOs for the development of strategies that allow for better destination management.

The prominent SciVal topics are available in the SciVal tool, which allows the evaluation of the quality of research and scientific production. The metrics and information provided by SciVal are based on Scopus data since 1996 [14]. Topic prominence is a measure of the visibility and momentum thereof [15]. In addition, they provide insight into whether a research topic is growing or declining; consequently, they are generally used as a key element to promote research funding [15,16]. Topic prominence is expressed through percentiles, the higher the percentile in which an article is placed, the greater its impact [17].

The United Nations 2030 Agenda defined a total of seventeen SDGs aimed at ending poverty, protecting the planet, and achieving prosperity for all [18]. Given that tourism is the fastest growing sector of the global economy, it is important to analyze its impact on sustainability [18]. In addition, digital tourist tracking techniques are supported by digital transformation, which in turn constitutes a potential support to the SDGs, as it enables the use of computer techniques to analyze trends and patterns in the information collected, and this is transformed into actionable information on human behaviors, the environment and experiences [19]. Such information helps political leaders formulate appropriate development programs, assess progress, and propose improvements [19]. The association of tourist tracking studies with the SDGs is relevant because it allows the recognition of the efforts that are being made in the tourism industry to achieve the sustainability goals proposed globally.

This study aims to analyze the research landscape on tourist tracking, through a bibliometric study. To achieve this general goal, the following specific objectives were proposed: (Objective 1, O1) to evaluate the performance of the publications; (O2) to recognize the prominent SciVal topics; (O3) to analyze the evolution of the techniques; and (O4) to recognize their use as a tool that contributes to the development of smart destinations.

The analysis resulting from this research is useful in the scientific and practical spheres. This study will be able to help researchers identify which authors, institutions, and countries are publishing in the area of tourist tracking, identify the benchmarks in this field, recognize the most cited publications, and the journals with the highest number of publications, and thus provide answers to questions such as, where and with whom to collaborate?, which journal should I publish in?, and which articles should I reference in my research? Likewise, this study will help to know the tourist tracking techniques that have been studied the most and to consider them for future studies, since there would be a greater probability of publishing such research and obtaining funding. This study is also valuable for the generation of knowledge and for decision-makers, such as tourism managers, tourism associations, public institutions, government, etc., as it allows them to understand and adopt the concepts of tourist tracking techniques, to understand the advantages of using them, and how the information obtained through them contributes to tourist satisfaction and sustainable management of the destinations.

This article is organized into seven sections. After this section, Section 2 presents the literature review, which summarizes the main tourist tracking techniques; Section 3 describes the methodology used for the development of the study; Section 4 covers the results obtained and their analysis; Section 5 shows the future challenges of research in tourist tracking; Section 6 includes the conclusions; and Section 7 presents the limitations of the study carried out and the recommendations for future bibliometric studies on the subject analyzed.

2. Literature Review

2.1. Tourist Tracking Techniques

For the selection and implementation of tourist tracking techniques, researchers in the tourism industry should consider the advantages and disadvantages of each technique, as well as the possibility of combining different techniques to obtain better results. In addition, the implementation cost thereof and the specificity of the data required should be considered. The main digital tourist tracking techniques are described below.

2.1.1. GPS Devices

This is a mainly active, high spatio-temporal resolution method, where GPS devices are handed over to the tourist [8]; this last feature makes the technique costly, in addition, it takes a long time to deliver the devices to the participants at defined entry and exit points [9].

Among the attributes of GPS data are longitude, latitude, time stamp, speed, direction, etc. [20]. Spatially rich databases on tourist movements are strongly associated with GIS (geographic information systems), which allow you to analyze space and time, and help to discover and understand the behavior of tourists in a destination [21].

In protected areas, knowing the spatial behavior of tourists is useful to balance human use and its impact with the protection of natural resources [22]. In addition, knowing, for example, the most frequented trails, can support management decisions related to the strategic allocation of infrastructure (interpretive boards, sign-posts, on-site maps, etc.) and the provision of specific tourist information [23]. Data obtained through the GPS tracking technique of tourists has been widely used in research related to the management of protected areas (Sugimoto, Ota and Suzuki [21], Švajda et al. [22], Taczanowska et al. [23]).

This technique has also been used in other environments, Shoval et al. [24] identified which places tourists were most likely to visit depending on the location of their hotel, from tracking tourists' movements on their day trips, using GPS devices. Spatio-temporal information on tourists can be used by organizations, from hotels to DMOs, to know the movements of tourists in destinations, and thus know which attractions tourists visit, which may not be the focus of marketing campaigns, and which are not visited, but are promoted [24].

2.1.2. App-Based GPS

An application is installed on a smartphone, and the phone's built-in GPS sensors automatically track tourists' movements in space and time based on the use of the application [25,26]. Like the GPS device, this technique provides high-resolution data in time and space [27]. This data can also be associated with other advanced technologies such as GIS [28].

This type of techniques poses some technical and methodological problems such as phones with limited memory, lacking space to download an application; applications with GPS functionality drain the battery; tourists must have a motivation to download the application on their phones [26]; and low tourist willingness to participate [9].

Hardy et al. [26] used mobile app-based GPS to track tourists' movements around regional destinations and attractions during their stay in Tasmania; concluding that the detailed nature of GPS data will allow DMOs to know the time tourists spend in the destination, the infrastructures that are used, and the places where it is necessary to have new infrastructures.

2.1.3. Mobile Networks

Mobile data is recorded by mobile network operators during the use of public voice and data networks by mobile devices [9]. This data is called "passive" because the user does not perform any activity to produce it; it is obtained only by having the device turned on. In addition, data is stored on the network, not on the device [8,9]. Likewise, many mobile phones can be tracked for long periods of time [29].

The accuracy of passive mobile data is somewhat lower than that of GPS data [20]. Also, obtaining this type of data is extremely difficult due to privacy and surveillance concerns, limiting its implementation [20]. Other disadvantages of this technique are its high cost and its dependence on mobile operators [12].

Mobile data makes it possible to identify the activities of tourists in the destination, enabling tourism researchers to segment travelers based on flows, and thus categorize destinations according to the activities carried out in them [30]. This information is important for demand-based destination planning, which is related to the vision of smart tourism design, in which operations and services are designed based on the collection and processing of large amounts of data [30]. In this sense, Raun, Ahas and Tiru [31] developed a study in which they measured the flows of foreign visitors in Estonia, based on mobile positioning data between 2011 and 2013, managing to recognize the places visited and whether they are connected or disconnected. The authors conclude that this information can be of great help in improving marketing and management decision-making.

2.1.4. Social Media

Social media allows users to share their tourism experiences, through online textual data (such as product reviews and blogs) and online photographic data [20]. It is common for social media users to tag posts (images, videos, text messages, etc.) with geo-location data; using applications such as Facebook, Twitter, Instagram, Foursquare, Flickr, and Weibo [8,26].

Data from online reviews, blogs, and other related textual style data is a special type of big data in tourism research as it conveys feelings, sensations, and moods of tourists [20]. On the other hand, as for the photos uploaded to the web, its analysis can show the most visited places, the time itinerary of tourists, the accommodation where they stay, and the places they liked the most [12].

The advantage of geotagged data from social media and online photo data is the large amount of data that can be collected in real time, over long periods of time and at large geographic scales [29]. However, the disadvantages of data from this source are that they are less accurate, and they tend to be very limited in terms of completeness and validity, because of the possibility of biased behavior on social media [8,29,32].

Orama et al. [10] developed a methodology using artificial intelligence techniques for the analysis of social media data. The method allows knowledge of the tourist's mobility patterns based on who they are and what their preferences are; information that can be used by DMOs to offer personalized services, attract different segments of tourists to certain places of interest, create new routes, or optimize public transportation services.

2.1.5. Operations in the Tourist Market

Tourism market transaction data refers to transactions, activities, and events in the tourism market, e.g., Internet searches, website visits, online booking, and shopping, etc. These data are not only useful for tracking tourists, but are also used for search engine optimization, behavioral insights, and tourism marketing [20]. However, they have limitations, such as dependence on a third party and ethical issues, due to data protection requirements [12].

In particular, electronic payments can be a reliable and timely indicator of tourism flows and demand, providing three levels of knowledge: monetary, spatial, and temporal [33].

Few studies in the tourism field have used electronic payments to track tourists, perhaps because of the privacy issues associated with their use. Adamiak and Szyda [34] conducted a study in which they made maps comparing the number of tourist visits and tourist spending in different destinations around the world, using official statistical sources (Eurostat) and Airbnb reviews as a proxy for the number of rental transactions. They identified hotspots, and found that domestic travel predominates in global tourism mobility. The authors concluded that the results can assist in more informed tourism planning at large territorial scales.

2.1.6. WiFi

A WiFi network can be used to count accesses to a location and estimate the position of users [35]. WiFi data is collected passively through signals, which travel in the air, sent by mobile devices, therefore requiring no action on the part of the participant [36]. In addition, these data constitute an emerging source for studying small-scale tourism activities [37]. The WiFi technique is similar to Bluetooth, but appears to be more convenient and low-cost [20], since WiFi data has a high spatio-temporal granularity and is somewhat cost-effective in relation to equipment installation and data collection [37].

The WiFi tracking technique has some limitations, such as: (1) Privacy issues; (2) The episodic nature of WiFi data, as WiFi signal strength can be affected by factors such as signal transmitting and receiving antenna characteristics, and environmental obstacles; and (3) Sampling biases, for example, the digital divide does not allow identifying those who do not own a smart device [38].

WiFi data has been used for analysis of crowd behavior and activity patterns, both indoors and outdoors [37], for example, to analyze the behavior of tourists in a tourism event, and therefore it is useful for tourism recommendation and emergency management [20]. In the field of tourism, in addition to being implemented in tourism events, it has also been implemented in community-based tourism. Li et al. [37] conducted a study in which they analyzed the spatio-temporal patterns of tourists at a community tourist attraction in Beijing using WiFi data over six months. The study provides information for the future sustainable management of community-based tourism, such as improving the locations of tourist reception sites and the formulation of strategies to control the flow of tourists [37].

The advantages and disadvantages of each of the tourist tracking techniques discussed above are listed in Table 1.

Table 1. Advantages and disadvantages of tourist tracking techniques.

Tourist Tracking Technique	Advantages	Disadvantages
GPS device	- High spatio-temporal resolution [8]. - Continuous data collection over an extended period of time [26].	- High cost [9]. - It does not consider the subjectivity of the tourist [26]. - It is necessary to meet with participants before and after the study [29].
App-based GPS	- High spatio-temporal resolution [27]. - Large sample size and real-time performance [39].	- Privacy concerns [39].
Mobile networks	- Data are collected without the direct participation of the tourist [40]. - Data collection at large geographic scales [29].	- Privacy concerns [20]. - High cost, dependence on mobile operators [12].
Social media	- Consider the subjectivity of the tourist [20]. - Real-time data collection at large geographic scales [29].	- Less spatial accuracy [29]. - Limited completeness and validity [8].
Operations in the tourist market (electronic payments)	- They are a reliable proxy of tourism demand [33]. - They provide three levels of knowledge: monetary, spatial, and temporal [33].	- Its application depends on specific infrastructure [33]. - Privacy concerns [12].
WiFi	- Data is collected passively [36]. - High spatio-temporal granularity [37]. - Low cost [20].	- Privacy concerns [38]. - Problems with WiFi signal strength may occur [38].

2.2. Gaps and Limitations of the Studies Analyzed

The following gaps were identified in the papers analyzed through the bibliometric study conducted:

First, there are few studies in which the simultaneous use of several tracking techniques is evaluated. The joint implementation of tracking techniques is beneficial, as the attributes of the techniques are leveraged and weaknesses are overcome.

Secondly, not all studies frame their contributions to the achievement of the SDGs. Considering the relevance of the 2030 Agenda for Sustainable Development, linking research to the SDGs is necessary to guide actions to achieve these goals.

Thirdly, there are no studies that address the costs associated with the implementation of tracking techniques, or in which a cost-benefit comparison of the use of different techniques in tourist destinations is made. This information would be important for DMOs and destinations, as from this information they could select the tracking technique(s) that fit their needs and, at the same time, fit their budgets.

Fourthly, no research has been carried out analyzing the implementation of strategies formulated based on the data provided by the tracking techniques in the destinations; existing studies only address data collection, data processing, and the contributions of research to destination management, and even propose strategies to address problems in tourism. For example, Hu et al. [41] developed a study proposing a strategy to generate dynamic and personalized tourist routes with less crowding at an urban scale, based on mobile positioning data; and conducted several experiments in the Chinese city of Dalian to evaluate and validate the proposed methods and strategies. But there are no studies that address how destinations have implemented these types of strategies and what results they have achieved with the implementation of these strategies.

On the other hand, some of the limitations identified in the tourist tracking studies analyzed are the following:

Representativeness of the sample in studies based on data obtained from social media, since in general, these are more used by the young population, excluding from the evaluation a sector of the tourist population, the elderly; this limitation is also present in studies in which the App-based GPS technique is used. On the other hand, another bias of social media data is the spatial accuracy.

Representativeness of the sample in studies that use mobile positioning data, as the researchers do not have the data of the different mobile phone operators in the study area, which can generate biases in the analyses. Another limitation found is the low spatial resolution of the data, in places where mobile base stations are sparsely distributed.

The analysis of only the spatial and temporal dimensions, when using tracking techniques such as GPS devices, leaves aside factors such as tourists' motivation, emotion, and affective values.

Lower accuracy of data collected with GPS in places such as buildings, wooded areas and narrow valleys.

3. Methodology

The objective of bibliometric analysis is to summarize large amounts of bibliographic data to determine the state of the intellectual structure and emerging trends of a field of research [42]. The bibliometric approach uses quantitative metric indicators, often over a period of time [43]. Moreover, it has a solid mathematical basis, offers quantitatively precise results, and reduces the biases of researcher subjectivity [44]. For these reasons, this research approach was selected to summarize and analyze the existing literature on tourist tracking and its impact on the sustainable management of destinations. Bibliometric studies have been widely used in tourism [43,45] with relevant results.

Bibliometric studies are not without limitations. Donthu et al. [42] points out the following: (1) Bibliometric data from scientific databases such as Scopus are not generated exclusively for bibliometric analyses, so they may have errors, which will affect the analysis carried out from them; (2) This type of study can only generate a short-term forecast of the field of research, considering the dynamic nature of scientific publications, therefore, long-term forecasts should not be made; (3) Since the results extracted from a bibliometric study are quantitative, a not very clear relationship is generated when making qualitative statements from such data, so care must be taken when making this type of statement.

The approach of this research is mainly quantitative (bibliometric study), however, it also analyzes the evolution of tourist tracking techniques from 2007 to the first half of 2023, their relationship with the SDGs, and their contribution to the development of smart destinations.

The bibliometric study followed the guidelines recommended by Donthu et al. [42] and used the R-Bibliometrix version 4.3.0 and VOSviewer version 1.6.19 software, as well as the SciVal tool. The process of article selection is described in Figure 1.

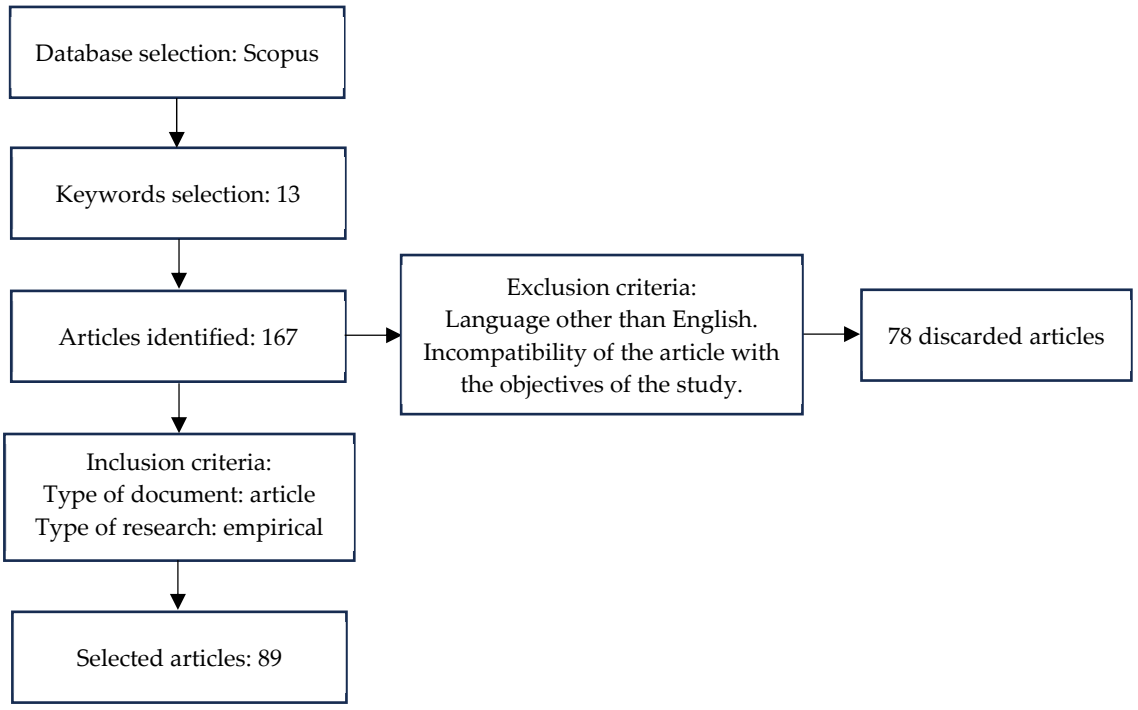

Figure 1. Process of article selection.

3.1. Database Selection

The articles used in this study were obtained from the Scopus database, which includes a great number of research papers published in leading peer-reviewed journals worldwide, making it an ideal database for bibliometric analysis [46].

3.2. Keywords Selection

A significant number of keywords were selected to cover as many articles as possible on tourist tracking. Furthermore, Boolean operators (OR/AND) and fuzzy search (*) were used to broaden the scope of the research [47]. The keywords used included:

TITLE-ABS-KEY ("tourist tracking" OR "Tourist spatial-temporal behavior" OR "Tourist spatial behavior" OR "Tourist temporal behavior" OR "mobility patterns of tourists" OR "visitor spatial behavior" OR "visitor activities and flows" OR "travel mobility patterns" OR "visitor's spatial and temporal behavior") OR TITLE-ABS-KEY ("Big data" AND "touris*" AND "mobility") OR TITLE-ABS-KEY ("Big data" AND "touris*" AND "tracking") OR TITLE-ABS-KEY ("touris*" AND "tracking" AND "mobility").

3.3. Criteria for Inclusion and Exclusion of Articles

The inclusion criteria to be considered were the type of document: article, and the type of study: empirical. Documents in a language other than English and those not directly related to the subject matter and objectives of the study were excluded.

3.4. Article Collection

The search for articles was conducted on 19 July 2023 and yielded a total of 167 papers. After considering the inclusion and exclusion criteria, 89 articles were selected for the development of the study.

3.5. Article Classification

The articles were read in depth and classified according to the tracking technique used; they were also classified according to their purpose, as supply or demand-driven, or both.

3.6. Bibliometric Analysis

The bibliometric analysis included both research performance analysis (journals, authors, institutions, and countries) and science mapping (citation analysis: most influential publications; co-word analysis: network of co-words; co-authorship analysis: collaboration between country-authors).

4. Results and Discussion

4.1. Statistical Summary of Publications

The annual production of publications is presented in Figure 2. Tourist tracking research is relatively new. The first empirical article was published in 2007; then, between 2011 and 2014 only two articles were published per year, except for 2012, where no publication was reported. Therefore, it is concluded that in the 2007–2014 period, there was little interest on the matter. Since 2015, there has been an increase in the number of publications, which shows that interest in the subject has increased over the years, thanks to advances in ICT, which have allowed new forms of tourist tracking to emerge, and the shift in destination management towards sustainability. The 2020–2022 triennium was the period with the highest scientific production, with 42 articles, indicating that nearly half of the selected articles were published recently. The deadline for article selection was July 19, 2023, therefore, the number of publications this year (8) does not represent a downward trend. Based on the behavior observed in recent years, it is expected that the number of publications will continue to increase over time.

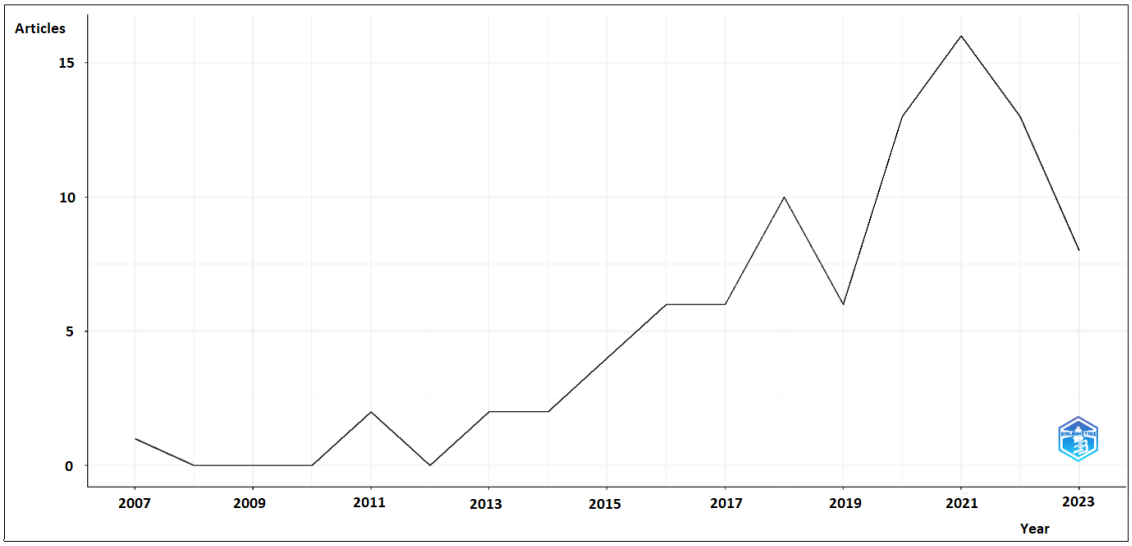

Figure 2. Annual scientific production of empirical articles on tourist tracking.

The statistical summary of the publications extracted from the Scopus database is presented in Table 2. This shows that the 89 articles selected were published in 45 journals, the annual growth rate is 13.88% and the average number of citations per document is 27.43, a high figure despite the fact that nearly 50% of the articles have been published in the last 3 years. On the other hand, there are a total of 268 authors; only 3 papers were written by one author and the average number of authors per paper is 3.7. This reflects the importance of collaboration in tourist tracking research; furthermore, 35.96% of the articles include international co-authorship. As for keywords, the authors used a total of 345.

Table 2. Statistical summary of the publications.

Description	Results
Timespan	2007:2023
Sources (Journals)	45
Documents	89
Annual Growth Rate %	13.88
Average citations per doc	27.43
References	4735
Author's Keywords (DE)	345
Authors	268
Authors of single-authored docs	3
Single-authored docs	3
Co-Authors per Doc	3.7
International co-authorships %	35.96

4.2. Journals

Empirical articles on tourist tracking are found in 45 journals. The most relevant journals, i.e., with the highest number of published articles are: Tourism Management (7), Annals of Tourism Research (6), Isprs International Journal of Geo-Information (6), Sustainability (Switzerland) (6), and Tourism Geographies (5).

Forty percent of the articles (36) were published in the top 10% journals by SJR (SCImago Journal Rank), which reflects the quality of the articles generated in this area. The best journals correspond to the most cited journals indexed by Scopus, as defined by the SJR metric. This metric measures the prestige of a scientific journal [48]. The SJR metric "ranks scholarly journals based on citation weighting schemes and eigenvector centrality" [48]; it weights the value of a citation based on the field, quality, and prestige of the journal from which the citation originates [49]. Figure 3 shows the top journals by SJR

with the highest number of articles published on tourist tracking. Considering the most relevant journals, and Figure 3, it is noticed that the two journals with the highest number of articles on tourist tracking, Tourism Management and Annals of Tourism Research, are among the best journals by SJR.

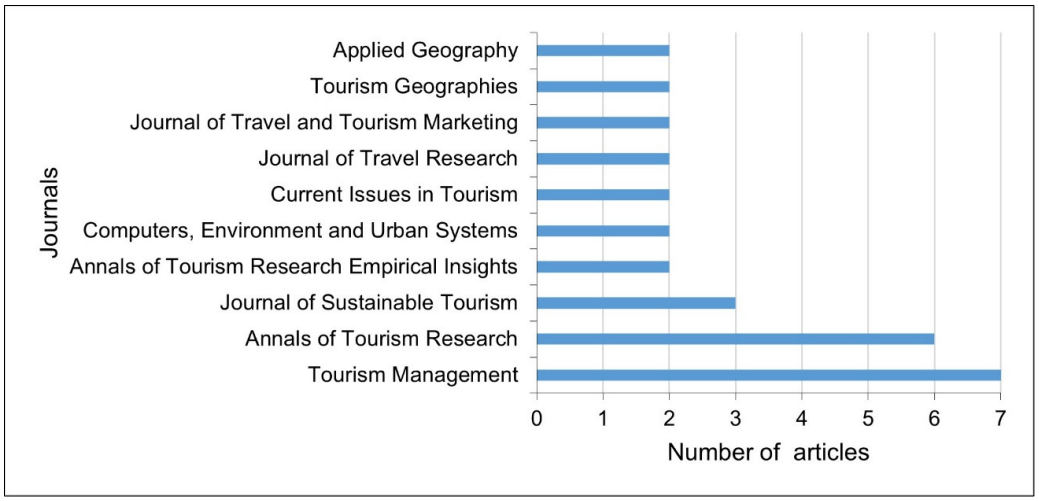

Figure 3. Number of publications in the top 10% journals by SJR.

4.3. Authors

The empirical articles on tourist tracking were written by 268 authors. Figure 4 shows the authors who produced most articles, and the distribution of publications by year from 2015 to 2023. The most productive author is Hardy A. with 7 papers, published between 2017 and 2022; followed by Park S. with 6 papers published in the last 3 years; and in the third position is D'Antonio A. with 5 papers between 2015 and 2022. On the other hand, Hardy A. is the author with the highest consistency in article production, with annual publications between 2017 and 2022, except for 2018.

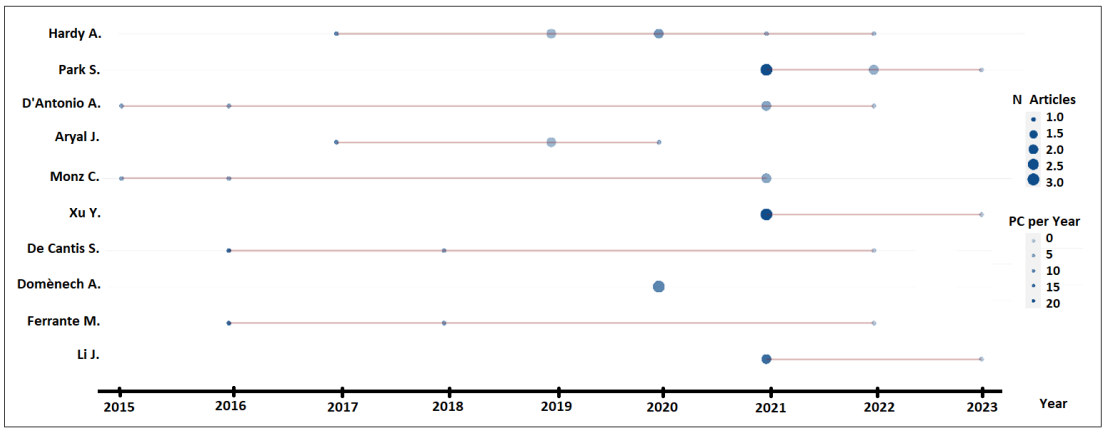

Figure 4. Top 10 authors' production over time. TC = total citation.

Table 3 shows the Top 10 authors with the highest impact, classified according to the h-index (The h-index for each author, obtained with the R-bibliometrix program, is calculated based on the group of publications on tourist tracking selected for this research, i.e., it corresponds to a local h-index). This is an indicator that reflects a balance between the number of publications ("productivity") and the number of citations per publication ("impact") [49,50]. Hardy A. is the author with the highest impact (h-index = 6) and is also the author with the highest number of publications (7); followed by Arial J. and Parks S., both with an h-index of 4.

Table 3. Top 10 authors based on the impact.

Author	University	Country	h-Index	Most Recent Publication
Hardy A.	University of Tasmania	Australia	6	2022
Aryal J.	University of Tasmania	Australia	4	2020
Park S.	The Hong Kong Polytechnic University	China (Hong Kong)	4	2023
D'Antonio A.	Utah State University	USA	3	2022
Domènech A.	Universitat Rovira i Virgili	Spain	3	2020
Monz C.	Utah State University	USA	3	2022
Shoval N.	The Hebrew University of Jerusalem The University of Pittsburgh	Israel USA	3	2018
Wells M.	University of Tasmania	Australia	3	2022
Xu Y.	The Hong Kong Polytechnic University	China (Hong Kong)	3	2023
Anton Clavé S.	Universitat Rovira i Virgili	Spain	2	2022

Table 4 shows the most cited articles. The article with the highest number of citations [51] analyzes several tourist tracking techniques: GPS, land-based TDOA tracking and hybrid solutions (GPS; land-based antennas-cellular triangulation; and AGPS). An experiment was carried out for each tracking technique to analyze the advantages and disadvantages of these techniques. In the second most cited paper, Raun, Ahas, and Tiru [31] developed a methodology for measuring visitor flows at destinations using mobile positioning data, which can be provided by mobile operators. The study focused on foreign tourists. The results allowed distinguishing tourist destinations within Estonia based on geographical, temporal, and visit composition parameters. The third most cited paper, ref. [52] reported several studies using GPS devices to find out how tourists moved around in two Australian cities. The results provided information to destination management agencies to improve tourist experiences through improved wayfinding systems. In the fourth most cited article, through the integrated use of a traditional survey and GPS technology, De Cantis et al. [53] proposed a set of indicators to analyze the mobility of cruise passengers in a destination and segmenting them. The results showed seven different major activity patterns and indicated that several sociodemographic and other passenger characteristics are associated with travel patterns at the destination. And in the fifth most cited paper, Zheng, Huang, and Li [54] collected information on tourists' movements using GPS technology and proposed a heuristic method to predict a tourist's next location. The results indicate that the proposed method performs significantly better than existing methods.

Table 4. Most cited articles.

Title	Author	Journals	Year	Total Citations
Tracking tourists in the digital age [51]	Shoval, N., Isaacson, M.	Annals of Tourism	2007	241
Measuring tourism destinations using mobile tracking data [31]	Raun, J., Ahas, R., Tiru, M.	Tourism Management	2016	165
Understanding tourists' spatial behaviour: GPS tracking as an aid to sustainable destination management [52]	Edwards, D., Griffin, T.	Journal of Sustainable Tourism	2013	140
Cruise passengers' behavior at the destination: Investigation using GPS technology [53]	De Cantis, S., Ferrante, M., Kahani, A., Shoval, N.	Tourism Management	2016	126
Understanding the tourist mobility using GPS: Where is the next place? [54]	Zheng, W., Huang, X., Li, Y.	Tourism Management	2017	123

Finally, Table 5 presents the top 5 articles according to the Field-Weighted Citation Impact (FWCI). This metric corresponds to the ratio between the total citations actually received by a document and the total citations expected for documents of the same document type (paper, review, book, or conference proceedings), publication year, and subject area, from the Scopus database [55,56]. The FWCI counts citations received in the year in which an article was published and in the following three years [49]. This metric considers the differences in research behavior between disciplines [56].

Table 5. Top 5 publications based on the FWCI.

Title	Author	Journals	Year	FWCI
Tracking tourists in the digital age [51]	Shoval, N., Isaacson, M.	Annals of Tourism	2007	7.18
Understanding the tourist mobility using GPS: Where is the next place? [54]	Zheng, W., Huang, X., Li, Y.	Tourism Management	2017	6.51
Cruise passengers' behavior at the destination: Investigation using GPS technology [53]	De Cantis, S., Ferrante, M., Kahani, A., Shoval, N.	Tourism Management	2016	5.93
Bottom-up touristification and urban transformations in Paris [57]	Freytag, T., Bauder, M.	Tourism Geographie	2018	5.49
Measuring tourism destinations using mobile tracking data [31]	Raun, J., Ahas, R., Tiru, M.	Tourism Management	2016	4.96

The FWCI is defined with reference to a global baseline of 1.0 [55]; that is, an FWCI of 1 means that the article has been cited exactly as would be expected according to the world average of similar publications [49]. The articles with the highest FWCI coincide with the most cited articles, except for the article by Freytag and Bauder [57]; this article identifies relevant tourist areas in Paris using GPS technology, these areas are taken as one of the inputs to explore and discuss about the interrelatedness of tourism growth and urban transformations in Paris. On the other hand, Table 5 shows that for all articles, the FWCI is greater than 1, this indicates that the publications have been cited more than would be expected based on the world average of similar publications. The study by Shoval and Isaacson [51], for example, has an FWCI of 7.18, which means that it has been cited 618% more than expected based on the world average.

4.4. Institutions and Countries

A total of 133 institutions have published empirical articles on tourist tracking, distributed in 34 countries. The institutions with the highest production of articles are: the University of Tasmania (18), the Hong Kong Polytechnic University (10), Utah State University (10), Universitat Rovira i Virgili (6), and the University of Palermo (6). Figure 5 shows that the most productive countries are China (16), Australia (9), the United States (9), and Spain (5), which is evidence of the interest of these countries in making their destinations increasingly smart. On the other hand, Figure 5 shows that about half of the publications from China and Australia are in collaboration with other countries, demonstrating that international collaboration is important in tourist tracking research.

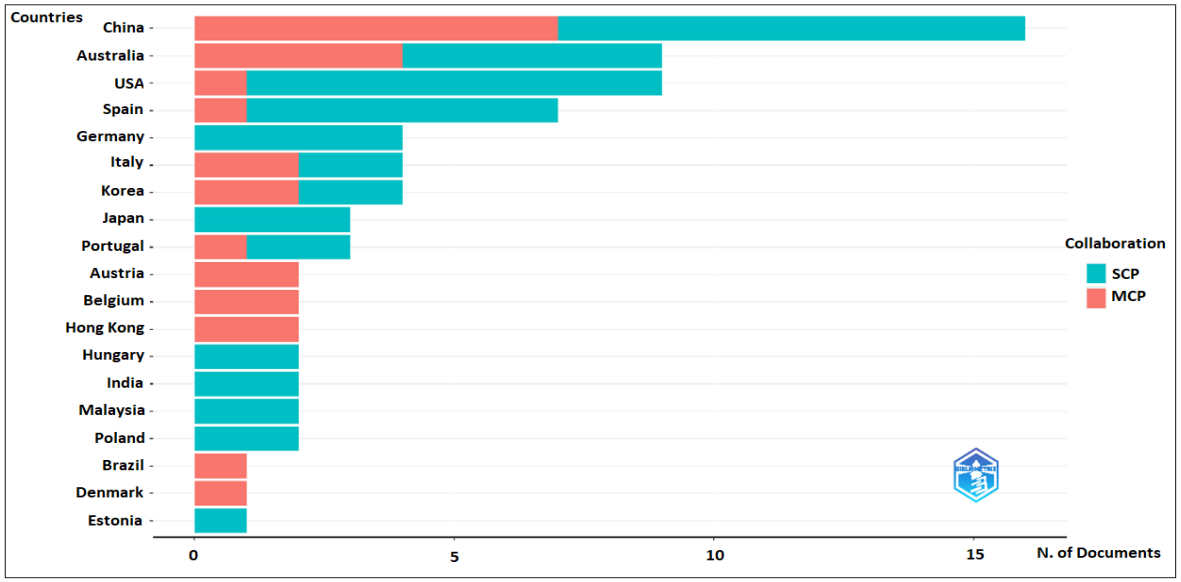

Figure 5. The most prolific countries. SCP: Single Country Publications, MCP: Multiple Country Publications.

4.5. Network Analysis

Figure 6 shows the collaborative networks among countries in tourist tracking research. The United States is the country with the highest number of collaborations (7), followed by China and Hong Kong (5), and Australia (4). Table 6 shows that publications with international and national collaboration have a higher number of citations (789 and 538, respectively) and higher FWCI (1.82 and 1.60, respectively), which reflects that collaboration increases the visibility and impact of the studies in the subject analyzed.The collaboration, using the FWCI, was analyzed only for articles in the period from 2013 to 2022 (78 articles) because it is the broadest range of years in which the SciVal tool allows the performance of the analysis. The results are considered significant because there are only 3 articles that were published before 2013 and 8 articles in 2023, some of the latter articles have not yet been cited because they are so recent, so there is not yet an analysis of their impact

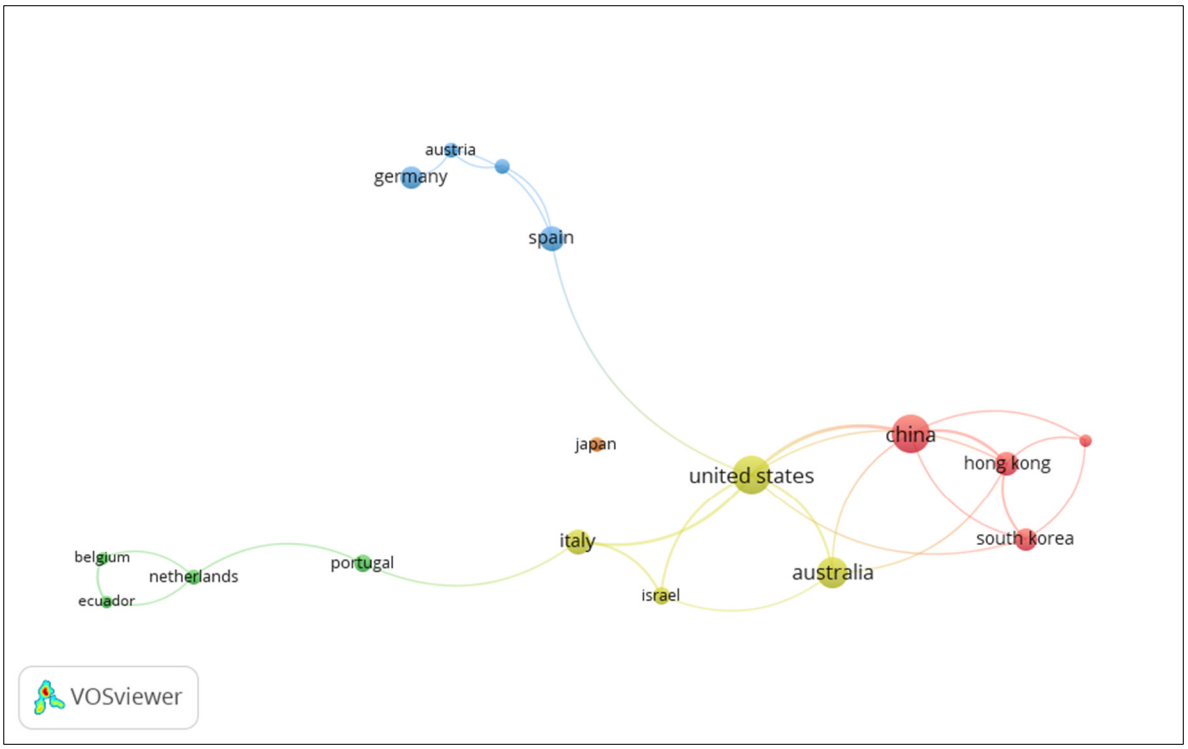

Figure 6. Collaboration between countries.

Table 6. International, national, and institutional collaboration in tourist tracking research.

Metric	Percentage of Publications	Citations	FWCI
International collaboration	38.50%	789	1.82
Only national collaboration	24.40%	538	1.60
Only institutional collaboration	34.60%	648	1.39
Single authorship (no collaboration)	2.60%	101	1.47

4.6. Keywords

Vosviewer version 1.6.19 software was used for keyword co-occurrence analysis. Figure 7 shows the main keywords and the relationships among them; the size of the circle represents the frequency of the keywords in the publications. Four clusters have been identified. The green and yellow clusters are associated with the GPS tracking technique (GPS devices and app-based GPS/GNSS), words such as spatial analysis, spatial behaviors are identified, which respond to what this technique is mainly used for; network analysis, which is one of the big data analysis techniques used for the treatment of data collected

with this tracking technique; GIS (geographic information system) allows the storage, organization, visualization, analyses, and simulation of geospatial data [58]; outdoor recreation, national parks, urban tourism, are associated with the areas in which this tracking technique has been used; and tourism development, which is the purpose for which it is applied in tourism studies.

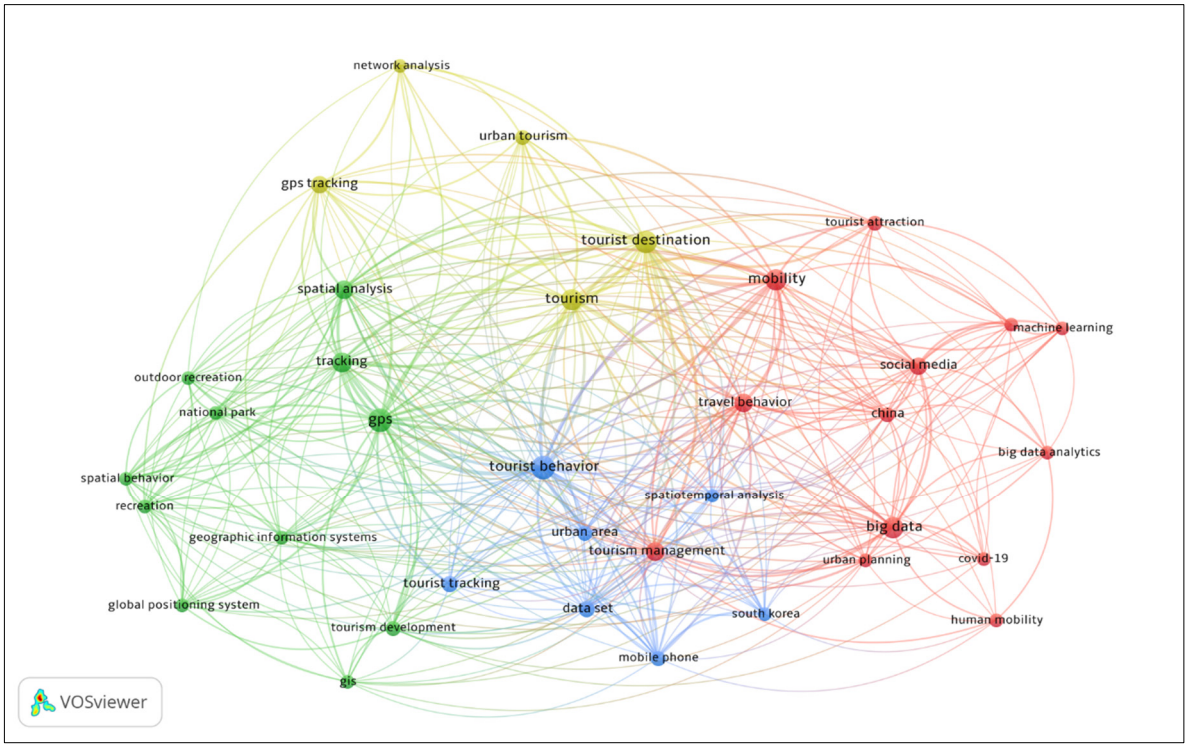

Figure 7. Keyword co-occurrence.

In turn, the red cluster is associated with the social media tracking technique. The terms big data, big data analytics and machine learning are identified—the latter is one of the analysis techniques used for the data obtained with this tracking technique; travel behavior, the connection of this term and social media tracking technique is logical because it allows knowledge and analysis of the behavior of tourists, more specifically, their preferences, desires, and feelings; this technique has been applied in areas such as mobility, urban planning, and studies related to COVID-19.

Finally, the blue cluster is associated with mobile networks. In this cluster, words such as mobile phone, urban area, tourist behavior, and spatio-temporal analysis are identified; this technique is mainly used for this type of dual analysis (spatial and temporal), to understand the behavior of tourists.

4.7. SciVal Topic Prominence

The SciVal topic prominence analysis was performed on 78 publications between 2013 and 2022; as previously explained, it is the largest period in which the SciVal tool allows the performance of the analysis. Thus, the analysis is performed on 88% of the publications under study, a significant percentage.

SciVal topic prominence combines three metrics: citation count in year n for articles published in n and $n - 1$; Scopus visit count in year n for articles published in n and $n - 1$; and average Journal CiteScore for year n. Topics are ranked according to the prominence of these citation patterns, which shows topic momentum in a specific area [15]. The publications under analysis are distributed in 21 prominent SciVal topics. Table 7 shows 10 of the topics identified, corresponding to the topics that comprise the largest number of articles and those that are closely related to tourism. Except for "Conservation

Areas; Trampling; Visitors" (PP-Prominence percentile: 84.83) and "Crowding; National Parks; Hiking" (PP: 86.96), the topics have a PP > 90, which means that they are among the 10% of topics with the highest visibility and momentum in the scientific field worldwide. The topics that include the highest number of publications are "Destination; Destination Management; Visitors" (41%) and "Human Mobility; Taxis; Points Of Interest" (23%), which shows that, for the most part, the focus of the studies has been on destination management and human mobility. Other relevant topics on tourist tracking are "Conservation Areas; Trampling; Visitors", "Destination Image; Competitiveness; Revisit Intention", "Smart Cities; Big Data; Internet of Things", "Destination; Ecotourism; Destination Management" and "Crowding; National Parks; Hiking"; all these topics are framed in the sustainability of the destination and contribute to the development of smart destinations.

Table 7. SciVal Topic Prominence.

Topic	Percentage of Publications	Prominence Percentile (PP)
Destination; Destination Management; Visitors	41.03	92.19
Human Mobility; Taxis; Points of Interest	23.08	99.57
Cruise; Tourism; Passengers	6.41	93.24
Conservation Areas; Trampling; Visitors	5.13	84.83
Travel Motivation; Music Festival; Destination	2.56	98.76
Destination Image; Competitiveness; Revisit Intention	2.56	98.86
Tourist; Destination Image; Risk Perception	1.28	99.87
Smart Cities; Big Data; Internet of Things	1.28	99.86
Destination; Ecotourism; Destination Management	1.28	99.80
Crowding; National Parks; Hiking	1.28	86.96

The identification of prominent SciVal topics by researchers in tourism, specifically on tourist tracking, is valuable as they can direct their studies towards these topics, which could encourage more corporate funding for the development of the studies.

4.8. Tourist Tracking Technique Evolution

Tourist tracking was originally done through surveys, interviews, direct observation, etc., but conventional surveys are generally costly and difficult to conduct, and direct observation requires an enormous amount of time [12,25,59]. With the new millennium, new technologies emerged, allowing the digital tracking of tourists. Figure 8 shows the tourist tracking techniques used between 2007 and the first half of 2023. The evolution of tourist tracking techniques has gone hand in hand with the evolution of ICT. The oldest empirical study analyzed was conducted in 2007, the techniques used were GPS devices, mobile networks, land-based time difference of arrival tracking (land-based TDOA tracking) and assisted GPS (AGPS); these techniques correspond to the technologies available at the time. Time Difference of Arrival (TDOA) is a land-based tracking technology, where thanks to a series of antennas that collect the transmissions of a final unit, the location of that unit can be known, through a triangulation process using time difference of arrival measurements from three stations [51].

Between 2011 and 2014, the techniques used were GPS devices and social media, specifically social media such as Flickr and Panoramio, which made it possible to track tourists through the photos posted on these platforms. Although these social media appeared in the middle of the first decade of the 2000s, their use in tourist tracking research came later, possibly because it was not until 2010, when 4G technology emerged in mobile networks, that users were able to experience smooth network access and high data speed [60,61], allowing them to take photos and upload them to social media anytime, anywhere; not only sharing photos, but also their comments.

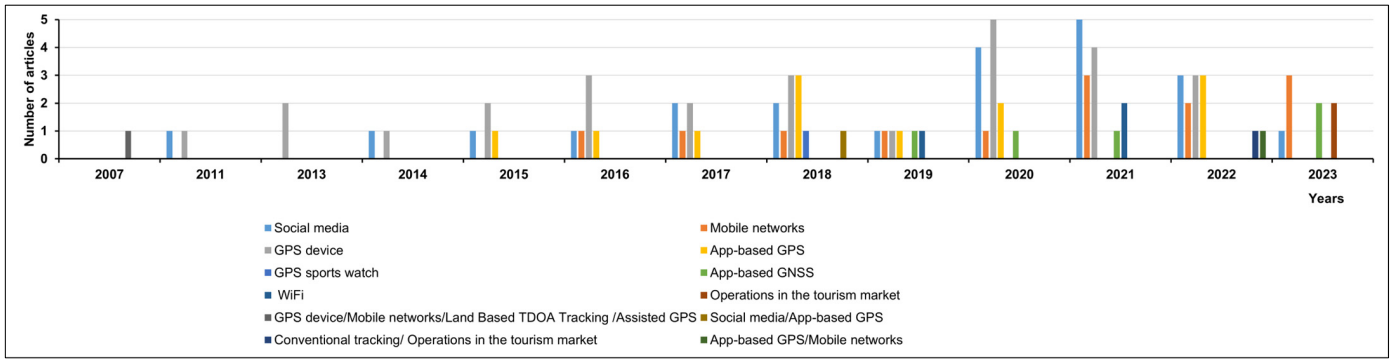

Figure 8. Tourist tracking techniques used in the period 2007–2023.

In 2015, the app-based GPS technique was used to track tourists, thanks to the fact that in previous years, the emergence of smartphones, such as the iPhone, led to the development of mobile applications that took advantage of cell phone GPS sensors to geolocate their users. Between 2015 and 2018, tourist tracking techniques included GPS devices, app-based GPS, mobile networks, social media, and GPS sports watches; with the highest frequency of use being GPS devices and app-based GPS. Between 2019 and 2022, WiFi technology began to be used for tourist tracking, as well as the use of operations in the tourism market; furthermore, in this period social media were used on a par with the GPS device technique. The increase in the use of social media for tourist tracking is possibly due to the fact that this technique not only enables spatio-temporal tracking, but also allows the attainment of information on the tourist's perceptions of the destination, preferences and interests; moreover, it is not intrusive. Thus far in 2023, the mobile networks technique has been the most widely used, but it should be considered that the studies are from China and South Korea, countries where it is possibly easier to access data from mobile network operators.

In a nutshell, in the period analyzed, tourist tracking techniques used have diversified based on the ICT evolution; the empirical studies analyzed began using techniques such as land-based TDOA tracking and AGPS, techniques that are no longer in use, and techniques such as GPS devices, social media, and mobile networks. Many techniques are currently available to analyze the spatial-temporal behavior of tourists.

On the other hand, the analysis of data collected from tourist tracking techniques also evolved over time; for example, in the case of social media, the oldest study analyzed, based on photographs from the Panoramio platform, used for data analysis GIS and statistics, more specifically, to identify hotspots, a non-parametric density estimation method called kernel density estimation [62]. In a subsequent study, Kádár [63] used photographs from the Flickr platform to distinguish tourists from residents by considering the tourists' stay in the destinations. Whereas, in the most recent studies that use social media, machine learning techniques, more specifically clustering techniques, were applied to analyze the spatial behavior of tourists [10,59]. Furthermore, studies such as those of Derdouri and Osaragi [64], which use Flickr photos, apply machine learning algorithms to differentiate tourists from residents and consider parameters that could explain the variability between the two (e.g., weather, mobility, and photo content); and do not rely on heuristic approaches (e.g., length of stay) to perform the classification as was done in previous studies. The different ways of analyzing data collected through tourist tracking techniques are gaining great interest in the studies, which has made data analytics an emerging topic.

4.9. Most Used Tourist Tracking Techniques

From the analysis of empirical studies on tourist tracking, four main techniques were identified: social media, GPS devices, app-based GPS/GNSS (Global Navigation Satellite Systems), and mobile networks. Figure 9 shows the tourist tracking techniques identified. The most used techniques are GPS devices (30%), social media (25%) and, app-based

GPS/GNSS (20%). The first is a pioneering technique in the tourist tracking, which is why it was used in most of the studies, and is also a high quality technique due to its precision. The second is a technique that in recent years has become one of the main techniques for tracking tourists, as previously mentioned, which allows the ability to obtain information not only in the spatial-temporal sphere, but also related to the interests, feelings, and perceptions of tourists. And the third, it can be said, is an improvement of the original GPS device technique, since satellite geolocation is integrated to a device as indispensable as the cell phone. Its use does not represent an additional burden for the tourist in the studies, but rather it takes advantage of the constant need to use this element in the daily life of people.

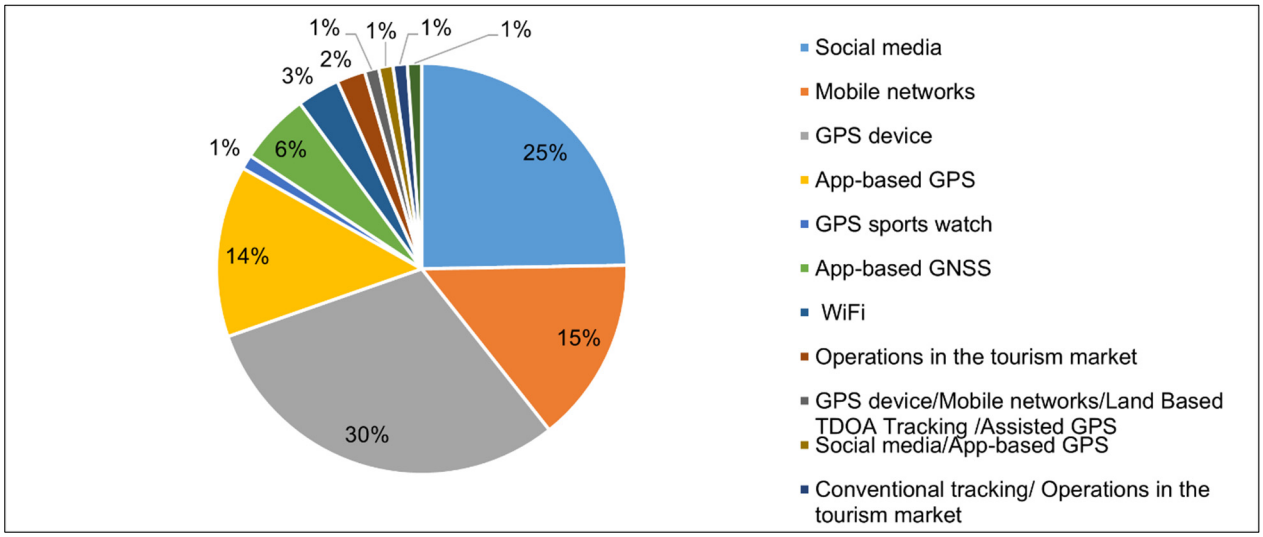

Figure 9. Tourist tracking techniques.

The tourist tracking techniques used in smaller proportions are: mobile networks (15%), WiFi (3%), and operations in the tourist market (2%). The studies also compared techniques (2%) and there was also a study in which the combination of the social media technique and app-based GPS was evaluated [65] to perform more in-depth analyses. The combination of tourist tracking techniques can favor the results obtained by taking advantage of the synergy between them.

4.10. Tourist Tracking Techniques and Their Importance in Destination Management

In the studies analyzed, tourist tracking techniques were used to understand the spatial and temporal behavior of tourists, identify hotspots in the destinations [62,66], segment the tourist population according to who they are and what their preferences are [10,30,53], define new tourist routes [41], know the spatial-temporal activity patterns of tourists [39,67], evaluate the behavior of tourist demand in the destinations [33,34,68], and evaluate the behavior of visitors in parks and protected areas [11,69,70]. Therefore, the implementation of tracking techniques contributes to improving destination management by providing DMOs with information on: (1) Spatial-temporal flows of tourists to control demand, generate new routes or optimize existing ones (reduce overcrowding and overtourism), predict tourist flows, and improve transportation services and infrastructure; (2) Tourist preferences, which is the basis for the design of new, more personalized tourism products and services; and (3) Tourist satisfaction for the evaluation of the services provided [10,30,32,71]. All this information guides decision-making and constitutes the axis of the creation of new marketing strategies and destination planning policies, helping their sustainable development [30].

The use of tourist tracking techniques can be focused on demand management, supply management, or both; 61% of the studies analyzed focused on demand, 38% on supply, and 1% on both. Figure 10 shows that the studies using the main tourist tracking techniques, GPS

devices, app-based GPS/GNSS, and mobile networks, were mostly focused on demand; with the exception of the social media technique, which was used in 50% for studies focused on both supply and demand. This technique is out of the trend because, due to its characteristics, it is possible to know the perceptions of tourists about a tourist destination, product, or service, which makes it very useful for managing the tourism supply. On the other hand, the only technique that has been used for studies focused only on demand is operations in the tourism market, due to its characteristics, but perhaps this is compensated by the fact that this technique can be used not only locally, but also on a regionally and even internationally. In the studies analyzed with this technique, the changes presented in the behavior of tourism demand in the destinations, originated by the COVID-19 pandemic, were evaluated at the municipal, regional, and global level [33,34,68].

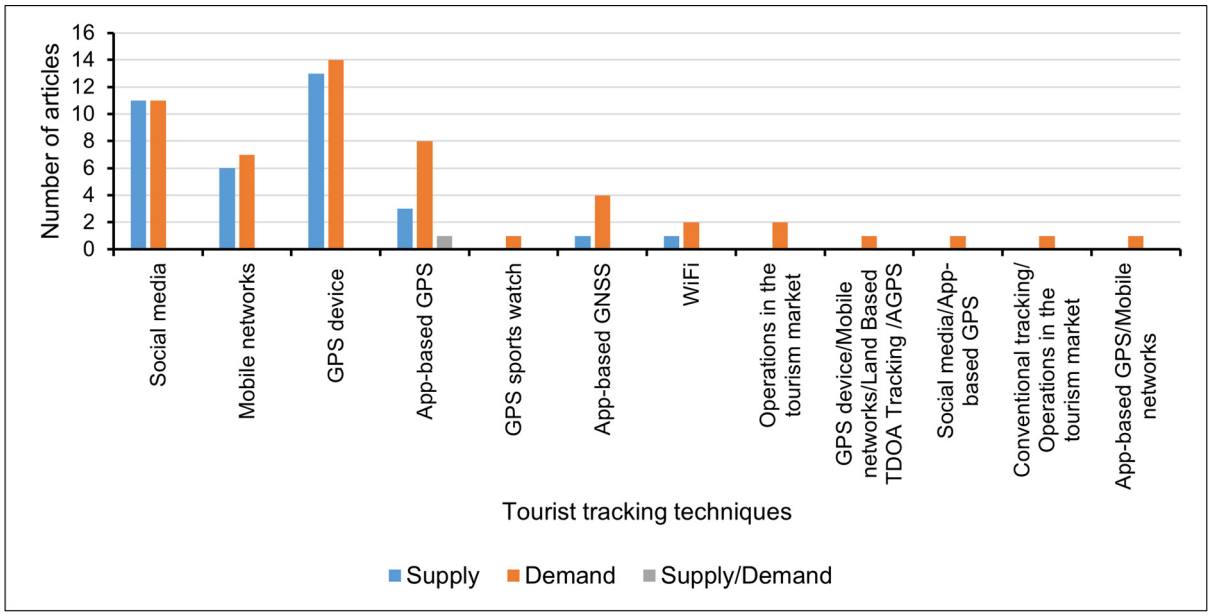

Figure 10. Approach tourist tracking techniques (supply and demand).

4.11. Tourist Tracking Techniques and Their Alignment with the SDGs

Achieving the SDGs is a task that involves all areas of society, including tourism. Taking advantage of the fact that for some of the publications, the Scopus database provides the SDGs to which they are linked, the SDGs to which the tourist tracking studies analyzed in this paper are related were identified, although they were not available for all the articles. The SDGs identified were: SDG3 Good health and well-being, SDG8 Decent work and economic growth, SDG9 Industry, innovation, and infrastructure, SDG11 Sustainable cities and communities, SDG12 Responsible consumption and production, SDG15 Life on land, SDG16 Peace, justice, and strong institutions, SGD17 Partnership for the goals. This reflects how the use of tourist tracking techniques can help in the fulfillment of the 2030 agenda.

The most frequent SDGs were SDG12 Responsible consumption and production (37 articles), SDG11 Sustainable cities and communities (22 articles), and SDG8 Decent work and economic growth (18 articles). This is because the information obtained with tourist tracking techniques can help manage overtourism in destinations with a large influx of tourists, can also provide tools to improve mobility in destinations, and in some way help sustainable urban planning. In addition, tourist tracking techniques involve the use of ICT, which improve the efficiency of destination management, favor the development of automated processes and promote the creation of innovative artifacts that improve tourism management. Consequently, it can be stated that the application of these techniques contributes to the development of smart destinations, which must develop five areas: governance, innovation, technology, sustainability, and accessibility [72]. Tourist tracking techniques play a significant role in sustainability, technology, and innovation.

On the other hand, only 10% of world scientific production is related to the SDGs [73]. Therefore, researchers on tourist tracking should consider the SDGs in the development of their studies, as this will make them more visible, influence their funding applications, and show the benefit of their studies in sustainability [73].

5. Future Challenges of Tourist Tracking Research

Multiple sources: The combining of different tourist tracking techniques makes it possible to obtain different types of data, covering greater dimensions: spatial, temporal, and emotional (feelings and preferences of tourists), which will enrich the analysis of tourist behavior, and in turn, provide greater knowledge for the management of destinations. Therefore, the combination of tracking techniques is a key aspect for the development of research [12]. This is confirmed by the study by Kovács et al. [74], which combined data from social media (Twitter) and mobile telephony to assess the flows of foreign tourists in the city of Szeged (Hungary) and obtained a more precise understanding of the behavior of tourists. Thanks to the joint use of tracking techniques, it was possible to know the motivations of tourists, the purpose of their stay, and the places they visited.

Data privacy: Guarantee the privacy of tourists' data so that they can collaborate in investigations without fear of their personal data being exposed. In this sense, Hardy, Birenboim, and Wells [75] argue that several investigations using the App-based GPS technique have had problems in their development due to the resistance of tourists to participate, probably because of concerns associated with the privacy of their data. For their part, Li et al. [20] point out that one way to solve the problem of data privacy is to sign confidentiality agreements and/or sensitive information exclusion agreements.

Tourists' favorite social media: Studies that include data from social media need to consider the most used social media among tourists, for example, Instagram, Twitter, and Facebook, in which tourists post photos and information about their trips. Existing studios have mostly leaned towards the use of Flickr, which is a platform where only geotagged photos and videos can be shared. Instagram, for example, in addition to photos (geotagged), provides information on the number of likes and comments, indicators of popularity that could be useful for the analysis of demand in destinations and the identification of the most popular sites [76]. Instagram also allows sentiment analysis based on tourists' comments, which is useful information for both tourists and governments (promotion of the destination, creating tourist guides and websites) [77]. On the other hand, the simultaneous use of different social media would favor the development of research, as it would provide complementary information and enrich knowledge [10].

6. Conclusions

Interest in tourist tracking has grown in recent years, which has led to an increase in the number of publications in this field. This study contributes to the knowledge of global trends in tourist tracking research, providing valuable tools for both researchers and DMOs.

The evaluation of publication performance showed the quality of the studies. A significant number of papers (40%) are published in the top 10% journals by SJR and, in general, the most cited articles have achieved the expected level of visibility (FWCI > 1). The most productive countries have been China and Australia, and collaboration among countries has been important since the studies with international collaboration have had a greater impact and visibility.

The prominent SciVal topics of most of the publications are among the topics with the highest visibility and momentum in the scientific field worldwide. In addition, the topic covered by the largest number of publications is "Destination; Destination Management; Visitors", which confirms that research on tourist tracking provides elements to address destination management.

Analysis of the evolution of tourist tracking techniques shows that they have advanced, both in terms of diversity and data analytics, given the evolution ICT. Among the techniques

identified, the most used have been GPS devices, social media, and app-based GPS/GNSS. However, it is worth noting that many recent studies have been developed with the second technique, due to the role that social media currently plays in people's daily lives, which facilitates the application of the technique, and also because of the comprehensive nature of the data collected (spatial-temporal data and tourist perceptions).

Aspects such as overcrowding and overtourism were little addressed in the studies analyzed. However, the lack of control of these phenomena generate problems for the tourism market: dissatisfaction of tourists; complications for tour operators when implementing the logistics of tourism activities; negative impacts on revisit and recommendation intentions [78]; and a negative image of the destination, hindering the marketing work of travel agencies and DMOs. Therefore, researchers need to pay attention to these aspects. Another aspect that needs more attention is the possibility of combining digital tourist tracking techniques and traditional techniques (for example, surveys), to provide more information about tourists. Greater knowledge of tourists would optimize the services provided by tour operators, travel agencies, etc., and, at the same time, improve the experience of tourists.

Existing studies on tourist tracking did not consider aspects such as cost-benefit analysis for the implementation of tourist tracking techniques, which would provide more tools to DMOs for the selection of techniques. Also, most of the studies do not show their linkage to the SDGs, which may probably reduce the interest of the scientific community and the tourism industry in the contributions they are making. Future studies could focus on these issues.

Likewise, new research can focus on the evaluation of the implementation of different tourist tracking techniques, which would increase the feasibility of the application of such techniques; and also, to be oriented to the analysis of the application in the destinations, of the strategies formulated from the data obtained with the tracking techniques, to reveal the real efficiency of the techniques. In addition, it would be valuable to generate a guide identifying the best tracking techniques based on a specific type of tourism, which would allow answering questions such as which techniques are more appropriate for community-based tourism or which for tourism in natural areas, etc.

Finally, the application of tourist tracking techniques is a key tool in the transformation of destinations into smart destinations, considering that they provide information to the DMOs to improve the supply of services and products, and control tourism demand, thus achieving a more sustainable management of the destinations.

7. Limitations and Future Studies

A limitation of the study was associated with the SciVal tool, although it is a valuable tool for bibliometric analysis, with which the researcher can only perform the analysis in the ranges of years predetermined by SciVal. Therefore, the FWCI and the prominent SciVal topics were analyzed only between 2013 and 2022; however, the results provided significant information to understand trends in tourist tracking research.

Future studies can address the analytics of the data collected through the different tourist tracking techniques, which was touched upon tangentially in this study, considering that this is an emerging topic that would provide important information to improve the application and analysis of the results obtained with these techniques. They could also include an analysis of empirical studies combining the use of different tourist tracking techniques, which will allow the most effective combinations to be proposed for implementation; this would be useful for the implementation of these techniques by DMOs.

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