

# **Big Data Analytics and Sustainable Tourism: A Comprehensive Review and Network Based Analysis for Potential Future Research**

## **Abstract**

The 2030 agenda for Sustainable Development is transforming the world. Sustainable tourism options are the forwarding steps for achieving that agenda by providing environmentally, socially, and economically sound tourism options. An increasingly important technology i.e., Big Data Analytics (BDA) can significantly benefit sustainable tourism regarding tourist destination selection, enhanced tourism experiences, and satisfaction. In this regard, the authors reviewed the extensive literature on BDA in sustainable tourism, traced the evolving trends, characterized the gaps, and provided recommendations for future research. The authors shortlisted 187 articles for in-depth analyses. A comprehensive literature review was developed, and a bibliometric study and network analyses were performed to analyse the extent and nature of BDA usage in the sustainable tourism area. The bibliometric study and network analyses helped the authors document the evolution and trends in applying BDA in sustainable tourism. Based on the literature review, a future research framework was developed by integrating BDA in sustainable tourism. The framework helped in envisioning relevant directions for future research. The article helps tourists, the tourism industry, the travel industry, and the hotel and hospitality service providers to gain insights into the benefits of using BDA in sustainable tourism and adopt BDA concepts and tools in tourism to help ensure improved tourist satisfaction.

**Keywords:** Sustainable Development Goal; Sustainable tourism; Big Data Analytics; Bibliometric analysis; Systematic literature review, Sustainable Societies

## **1. Introduction**

The tourism sector is one of the most significant economic growth and development sources in some countries (Brida et al., 2020; Kar et al., 2021). The leaders of the tourism sector tend to be proactive and anticipative within this highly dynamic business. Tourism contributes to many countries' economic development and GDP, specifically in the European region, where five countries are among the top ten tourist destinations in the world (Rodríguez et al., 2020). Travelling is an increasingly important part of many people. A survey by UNTWO showed that approximately 1.4 billion people travelled during 2019 (Streimikiene et al., 2020; Verma et al., 2022). According

to the world travel and tourism council, as of 2020, the tourism industry is projected to be the world's largest economic sector which provides 330 million jobs worldwide and contributes to 10.3% of the world's GDP (Croes et al., 2021). However, due to the COVID-19 pandemic, those projections will certainly not be fulfilled! Perhaps, after widespread usage of effective vaccines, the COVID-19 pandemic will become history, and tourism will increase again (Obembe et al., 2021). Although tourism has many positive economic benefits, it has an array of negative impacts. It increases energy consumption, the expansion of tourism causes nature deterioration and increased climate changes, increases in transportation-related fossil fuel usage (Xu et al., 2020). In addition, tourism has significant harmful impacts on the environment (Streimikiene et al., 2020). To reduce the harmful environmental impacts of tourism, many are working to develop and implement 'sustainable tourism, which is gaining importance in the tourism sector (Grilli et al., 2021). This review focused on the evolving roles of big data and information technology (IT) in the tourism industry, with a special focus on how IT usage may help enhance the 'sustainability of tourism.'

The usage of IT in the tourism industry had increased in recent years, beginning in about 2000 when the tourism, travel, and hotel industry sector began to use IT tools such as e-ticketing and online hotel booking (Perez Guilarte and Barreiro Quintans, 2019; Samara et al., 2020). Today's tourism sector provides various services through online platforms and social media to enhance tourists' experiences (Sharma et al., 2021; Kitsios et al., 2022). Big Data Analytics (BDA) is a disruptive technology that has had a significant impact on the tourism sector (Li et al., 2018; Samara et al., 2020). Usage of GPS is being used to analyse tourist travel patterns, which enhances tourism forecasting (Buning and Lulla, 2020; Kumar et al., 2022). The increasing demand for tourism consumes enormous amounts of resources. Consequently, tourism is causing nature degradation and increasing fossil-carbon emissions contributing to accelerating climate change causing. emissions (Paiano et al., 2020). The evolving 'Sustainable tourism' efforts are being designed and implemented to reduce the negative impacts of tourism (Paiano et al., 2020). It can help to reduce the need for transportation and other environmentally harmful aspects of tourism by utilising BDA information technologies. Recent studies underscore the tourism efficiency improvement advantages of using BDA in tourism (Del Vecchio et al., 2018; Alaei et al., 2019; Chun et al., 2020). A wide array of applications of BDA have been documented (Grover and Kar, 2017; Gupta et al., 2018; Line et al., 2020). But adoption of BDA has not been fully explored in

the sustainable tourism sector. The review highlighted contributions made by researchers in the field of BDA in sustainable tourism. The Bibliometric study was conducted to analyse significant contributions by researchers, institutions, journals, various sources and by countries (Naz et al., 2022) in the field of BDA in sustainable tourism. The network analysis was done to gain insight into the collaboration network among authors and countries (Agrawal et al., 2022) doing research in the field of BDA in sustainable tourism. Research evolution and trends in the field of BDA in sustainable tourism were analysed based upon the bibliometric study and the network study. Additionally, this study develops a research framework to support future research to help tourists, the tourism industry, the travel, hotel, and the broader hospitality service providers to understand the benefits of adopting BDA in making progress in achieving more sustainable tourism.

Therefore, this article proposes a Systematic Literature Review (SLR) of the evolving benefits of usage of BDA in sustainable tourism. The following research questions were used to guide the review:

*RQ1.* How is BDA being used in the tourism industry to enable more sustainable tourism?

*RQ2.* What are the current research areas of BDA in sustainable tourism?

*RQ3.* What are future research areas for BDA usage to improve sustainable tourism?

Based on the research questions, this study aimed to explore the previous studies depicting the significance of BDA in tourism, enabling sustainability in the tourism sector. Further, it aimed to systematically review the applications of BDA in the tourism industry, ensuring sustainable tourism. Then finally, it aimed to recognize and understand the present research breaches and future opportunities for inculcating the use of BDA in tourism for its improvement.

This paper was developed based on the SLR, the bibliometric study, and the network analysis of published articles in BDA in sustainable tourism. Many methods are available to conduct literature reviews, such as meta-analysis, narrow review, and systematic literature review (Yang et al., 2017). Meta-analysis mainly focuses on the statistical analysis of articles and is effective in comparing different research designs. The narrow review has limitations in quantification of the relevant literature patterns (Yang et al., 2017). Therefore, considering those limitations, the authors used the SLR methodology for this review. This paper was divided into seven sections: The first contains the introduction on the topic. The second section deals with SLR and the review methodology. The third contains the Bibliometric study. The fourth contains the network analysis.

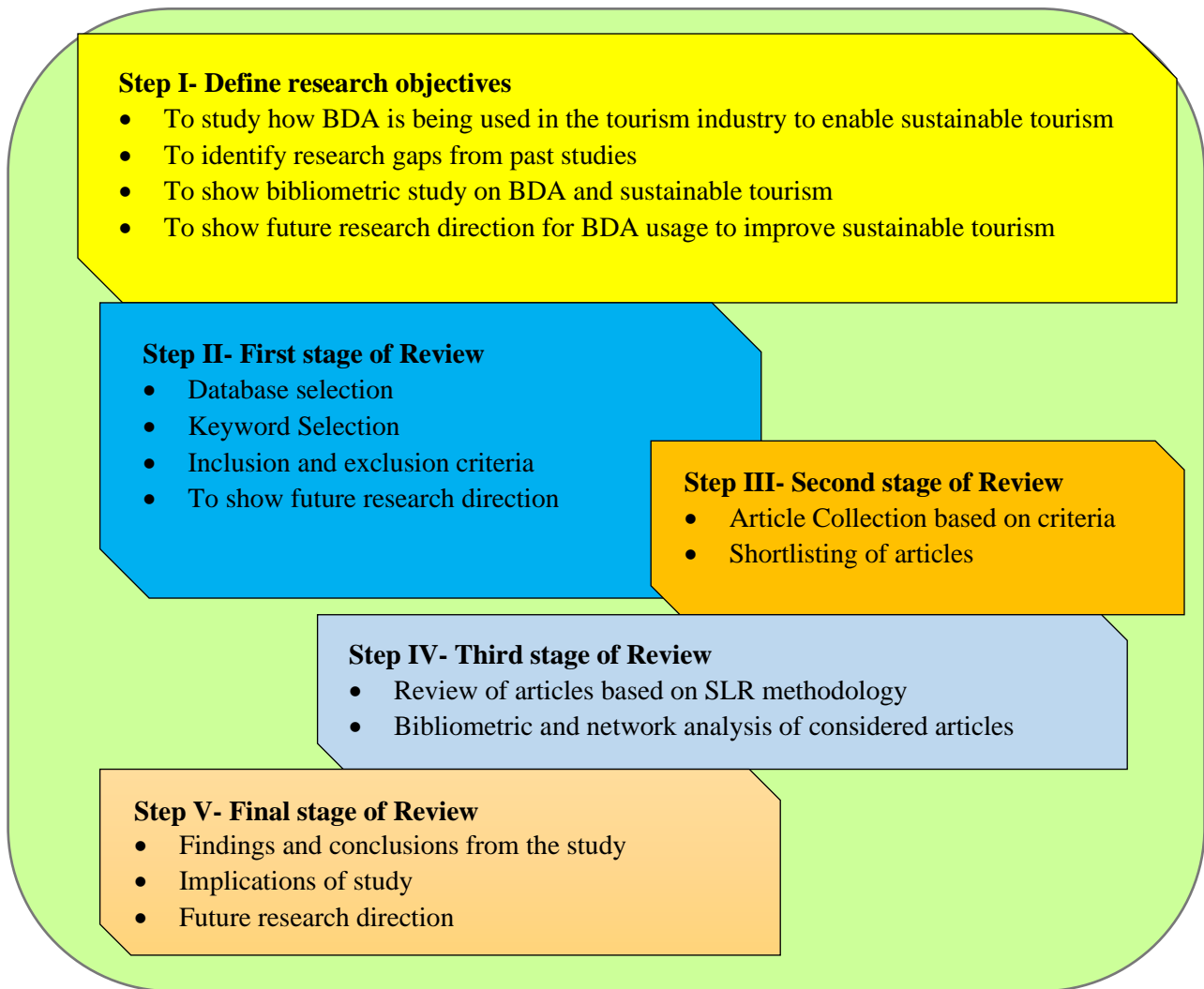
The fifth contains the discussion and the implications of the paper. Finally, the sixth includes the conclusions, limitations of the study, and suggestions for future research in this area.

## 2. Methodology

The methodology used in this study for a systematic review of considered articles is the SLR methodology (Sihag and Sangwan, 2020). It helps in a systematic review of published work and analyses current research trends, and research gaps associated with the considered area.

### 2.1 Systematic literature review

The flowchart of adopted SLR methodologies is presented in Figure 1.



**Figure 1:** The SLR methodology framework used in this study of BDA in sustainable tourism

As presented in Figure 1, the methodology began with defining the research objectives in which the research objectives have been framed. Further, step 2 includes the first stage review in which database selection, keyword, inclusion-exclusion criteria etc. were executed. After the first stage review, a second stage review was carried out as mentioned in step 3 in which the collection and shortlisting of articles were done. The third stage of review includes review analysis and bibliometric and network analysis. Finally, findings and conclusions from the study, implications of the study and future research direction were derived. The detailed understanding of each stage has been explained in further sections.

## **2.2 Selection of Databases**

In this study, we used SCOPUS, Web of Science (WOS), Google Scholar, and Science direct databases to find relevant articles based upon keyword searches (Wamba and Queiroz, 2021; Santos et al. 2021). The articles were collectively combined from all the databases and merged in a single file. Common articles from different databases were deleted.

## **2.3 Selection of Keywords**

This work aims to analyze the adoption of BDA in sustainable tourism based on a literature survey. The selection of keywords is an essential aspect of article collection in any field. In this work, the following keywords were considered for article collection on BDA adoption in sustainable tourism:

Title, abstract, and keywords (“Tourism” OR “Tourist” OR “Aviation” OR “Travel” OR “Hospitality” OR “Journey” OR “Leisure” OR “Traveller” OR “Heritage” OR “Hotel” OR “agritourism” OR “agri tourism” OR “agricultural tourism” OR “ecotourism” OR “rural tourism”)  
AND

Title, abstract, and keywords (“Big data” OR “volume data” OR “vast data” OR “data mining” OR “consumer review\*” OR “customer review\*” OR “tourist review\*”)

AND

Title, abstract, and keywords (“sustainab\*”)

## **2.4 Defining Inclusion and Exclusion Criteria**

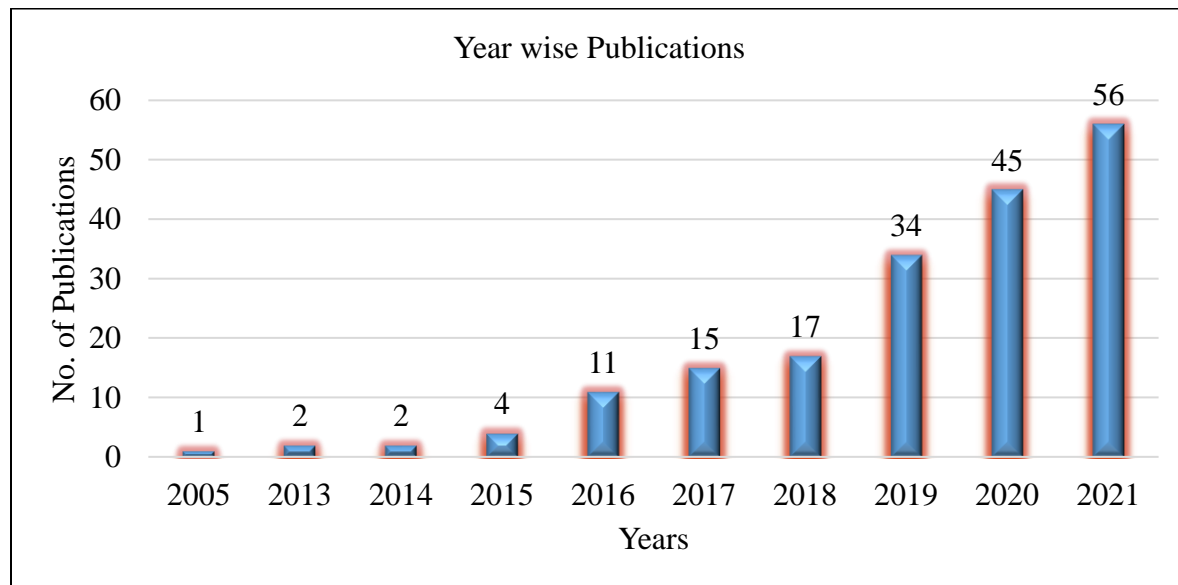
In this work, inclusion criteria were; peer-reviewed journals and review articles. One more inclusion criteria were the article should be in the English language. Exclusion criteria for this work were; conferences, book chapters, books, magazine articles, articles written in other languages, non-refereed conferences, and journals.

### 2.5 Articles Collection and Shortlisting on BDA in Sustainable Tourism

Based on selected keywords, 358 documents were identified. After applying inclusion and exclusion criteria, 187 articles were shortlisted based on their relevance to the study and focused on BDA in sustainable tourism. Duplicate articles were removed. A total of 187 articles was selected for review on the topic BDA in sustainable tourism.

### 3 The Bibliometric Analysis of the Articles Selected for this In-Depth Literature Review

The authors used different bibliometric packages for the bibliometric study. Some of them are widely used: Gephi, Pajek, VOS viewer, R package, and HistCite (Sharma et al., 2020). This paper used the R package and the VOS viewer for the bibliometric study and network analysis. In this regard, the number of articles selected for review is presented per year, as shown in Figure 2.



**Figure 2:** Year-wise publications in the field of BDA in sustainable tourism

From Figure 2, the increasing trend of relevant articles is evident from 2016. The number of articles was 11, followed by 15, 17, 34, 45, and 56 articles in 2016, 2017, 2018, 2019, 2020, and 2021 respectively. It has been found that there is a sudden increase in the trend of publications from 2018 to 2019, which is a 100% increase from 17 to 34. This study divides the bibliometric study into four categories: document statistics, author statistics, country-wise statistics, and keyword study.

### 3.1 Document Study of Shortlisted Articles in the Area of BDA in Sustainable Tourism

The summary of 187 articles considered for review in BDA in sustainable tourism is presented in Table 1.

**Table 1:** Bibliometric analyses summary results of the 187 articles considered for the comprehensive literature review.

<b>Description</b>	<b>Results</b>
<b>Main Information About Data</b>	
Time Range	2005:2021
Article Sources including Journals, Books, etc.	111
Considered Documents	187
Average years from publication	1.87
Average citations per doc	12.67
Average citations per document per year	2.937
Total cited references cited within 187 articles considered for this study	10080
<b>Document Types</b>	
Articles	178
Reviews	9
<b>Document Contents</b>	
Keywords Plus (ID)	1028
Author's Keywords (DE)	751
<b>Authors</b>	
Authors	621
Author Appearances	674
Authors with single-authored documents	28
Authors with multi-authored documents	593
<b>Authors Collaboration</b>	
Single-authored documents	29
Documents per Author	0.301

Authors per Document	3.32
Co-Authors per Documents	3.6
Collaboration Index	3.75

Table 1 contains information about the shortlisted articles in the area of BDA in sustainable tourism. The total number of considered documents was 187, out of which 178 were research articles and nine were review articles. The total keywords used were 1028. It can be seen that the total number of authors doing research in the field of BDA in sustainable tourism was found to be 621, out of which 28 authors had published papers as single authors. In addition, 593 authors published multi-author articles. The top ten publishing sources in the field of BDA in sustainable tourism are listed in Table 2.

**Table 2:** The top ten publishing sources in BDA in sustainable tourism

Year	Total
Sustainability (Switzerland)	35
Journal of Sustainable Tourism	6
Journal of Coastal Research	5
Current Issues in Tourism	4
Tourism Management	4
Journal of Cleaner Production	3
Sustainable Cities and Society	3
Transportation Research Part C: Emerging Technologies	3
IEEE Access	3
International Journal of Sustainable Transportation	3

This study found that Sustainability (Switzerland) and Journal of Sustainable Tourism were the leading publishers of relevant articles in BDA in sustainable tourism with 35 and 6 articles, respectively. Still, relevant articles were also published in the Journal of Coastal Research, Current Issues in Tourism, Tourism Management, Journal of Cleaner Production, Sustainable Cities and Society, Transportation Research Part C: Emerging Technologies, IEEE Access, and International Journal of Sustainable Transportation.

### 3.2 Authors Statistics



The author's data were analysed using R-package to identify the leading authors in the field of BDA in sustainable tourism, which are listed in Table 3.

**Table 3:** Top ten authors in the area of BDA in sustainable tourism

<b>Authors</b>	<b>Articles</b>
Liu X	4
Del Vecchio P	3
Hu J	3
Zhang J	3
Cui J	2
Dong L	2
Fitchett JM	2
Ge J	2
Guo Y	2
Hasan U	2

It can be seen that Liu X is the topmost contributing author with 4 articles in the field of BDA in sustainable tourism. Further other important authors working in investigating field are Del Vecchio P, Hu J, and Zhang J, with 3 articles each.

### 3.3 Institutional Statistics

Universities and Institutions' data were analysed using R-package to identify institutions and universities' statistics. It helps in identifying top institutes contributing to the field of BDA in sustainable tourism. The top institutes contributing to the field of BDA in sustainable tourism are presented in Table 4.

**Table 4:** Top 10 contributing organizations in the field of BDA in sustainable tourism

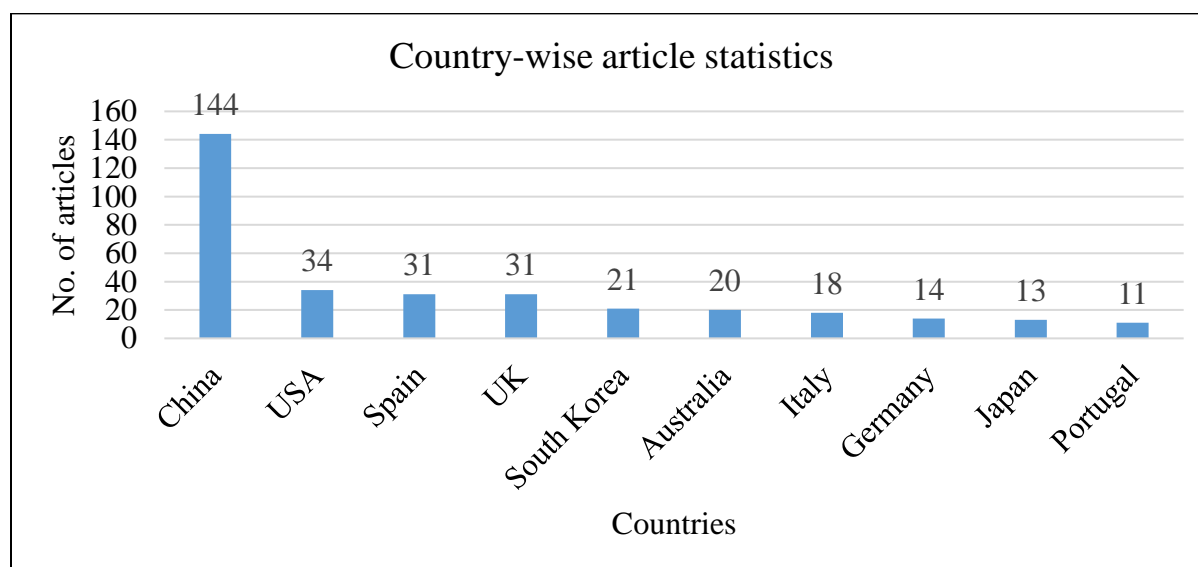
<b>Affiliations</b>	<b>Articles</b>
Shenzhen University	6
Beijing Normal University	5
Peking University	5
Southeast University	5
Sun Yat-Sen University	5
University of Helsinki	5
Nanjing Normal University	4
The Hong Kong Polytechnic University	4
Ton Duc Thang University	4

University of Leeds	4
University of Leipzig	4

It can be found that Shenzhen University is the leading institution working in BDA in sustainable tourism with a total of 6 published articles in the considered field. It is surprising to see that; the top five institutes are from China.

### 3.4 Country-Wise Statistics

Country-wise data extracted from different databases were analysed using the R package to identify the country-based statistics. Figure 3 shows the top ten countries with researchers working in BDA in sustainable tourism.



**Figure 3:** The top ten countries with researchers publishing articles in BDA in sustainable tourism.

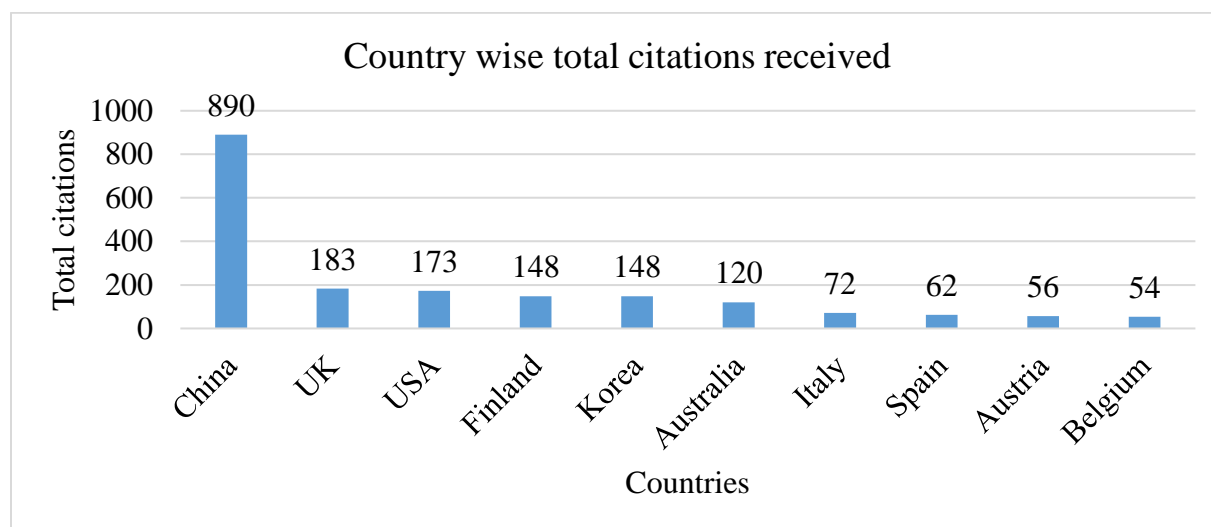
It can be concluded that China, the USA, and Spain were the top three countries with 144, 34, and 31 published articles in BDA in sustainable tourism. Corresponding authors' countries were analyzed using the R package; the results are presented in Table 5.

**Table 5:** Corresponding author's countries in the field of BDA in sustainable tourism

Country	Articles	Frequency	SCP	MCP	MCP Ratio
China	52	0.344	38	14	0.269
Korea	12	0.079	9	3	0.250
Spain	11	0.072	8	3	0.273

United Kingdom	11	0.072	6	5	0.455
Italy	8	0.052	7	1	0.125
Australia	5	0.033	5	0	0.000
USA	5	0.033	3	2	0.400
Belgium	4	0.026	1	3	0.750
Hong Kong	4	0.026	0	4	1.000
China	52	0.344	38	14	0.269

It can be concluded that China, Korea, Spain, and the UK had the highest number of corresponding authors who published articles in BDA in sustainable tourism with 52, 12, 11 and 11 articles. The analysis of the corresponding author's countries was documented according to Single Country Publications (SCP) and Multi-Country Publications (MCP). Furthermore, the country-based citation data were analysed using R package and is shown in Figure 4. They were documented according to the total number of citations per country in BDA in sustainable tourism.



**Figure 4:** The top ten countries of scientists who received citations in BDA in sustainable tourism

From Figure 4, it is found that Australia and The United Kingdom were the leading countries according to the number of citations of their scientist's documents published in the field of BDA in sustainable tourism.

### 3.5 Citation Statistics

Citation data were analysed using the R package based on collected data from different databases in the field of BDA in sustainable tourism. Year-wise citation statistics in the area of BDA in sustainable tourism are shown in Table 6.

**Table 6:** Year-wise citations of documents in the field of BDA in sustainable tourism

Year	No. of Articles	Average total citation per article	Average total citation per year	Citable Years
2005	1	11.000	0.688	16
2006	0	0.000	0.000	0
2007	0	0.000	0.000	0
2008	0	0.000	0.000	0
2009	0	0.000	0.000	0
2010	0	0.000	0.000	0
2011	0	0.000	0.000	0
2012	0	0.000	0.000	0
2013	2	142.500	17.813	8
2014	2	39.000	5.571	7
2015	4	69.750	11.625	6
2016	11	55.182	11.036	5
2017	15	17.600	4.400	4
2018	17	15.118	5.039	3
2019	34	11.265	5.632	2
2020	45	3.756	3.756	1
2021	56	0.661		0

It can be seen that average citations were the highest for articles published in 2013, with 142.5 average citations. This was followed by articles published in 2015 with 69.75 average total citations. Thus, citation analyses helped in identifying the leading documents in BDA in sustainable tourism.

**Table 7:** Top ten cited documents in BDA in sustainable tourism

Cited References	Total Citations	TC per Year
Sun et al. (2016)	452	75.333
Vu et al. (2015)	189	27
Jäppinen et al. (2013)	144	16
Vilajosana et al. (2013)	141	15.667
Tao et al. (2014)	76	9.5

Poslad et al. (2015)	66	9.429
Ettinger et al. (2018)	55	13.75
Kim et al. (2019)	51	17
Encalada et al. (2017)	45	9
Kim and Kim (2017)	43	8.6

From Table 7, it is clear that an article by Sun et al. (2016) achieved the highest global citation of 452, followed by Vu et al. (2015) with 189 citations and Jäppinen et al. (2013) with 144 citations documented in the field of BDA in sustainable tourism. Sun et al. (2016) discussed applications of IoT and big data for smart and connected cities. Vu et al. (2015) proposed a new approach to analysing travel behaviour using geotagged photo dataset. Jäppinen et al. (2013) analyse the impact of the bike-sharing system on travel time.

**Table 8:** The top ten author teams in the area of BDA in sustainable tourism of articles

Cited References	Citations
Encalada et al. (2017)	7
Vu et al. (2015)	5
Gerdt et al. (2019)	3
Del Vecchio et al. (2018)	3
Sun et al. (2016)	2
Jäppinen et al. (2013)	2
Tao et al. (2014)	2
Kim et al. (2019)	2
Nilashi et al. (2019)	2
Saura et al. (2018)	2

Local citations mean citations received by articles from shortlisted articles (citations received from the 187 shortlisted articles). At the same time, global citation refers to citations received by articles from the comprehensive considered databases. From Table 8, it is evident that the article by Encalada et al. (2017) achieved seven citations, followed by Vu et al. (2015) with five citations for articles in the field of BDA in sustainable tourism.

### 3.6 Keywords Statistics

Keywords statistics have been analysed by collecting data from considered databases. It helps to analyse the frequently used keywords in the article's keywords section. A total of 1028 keywords

were used in the selected articles, out of which the most frequently used keywords were highlighted as shown in Table 9.

**Table 9:** The top twenty keywords used in BDA in sustainable tourism

<b>Words</b>	<b>Occurrences</b>	<b>Words</b>	<b>Occurrences</b>
Sustainable development	39	Travel behaviour	12
Sustainability	32	Decision making	11
Big data	26	Environmental protection	11
Data mining	26	Tourist destination	11
China	23	Tourism management	10
Ecotourism	18	Urban area	10
Tourism	18	Urban transport	10
Data set	14	Article	9
Public transport	12	Tourism development	9
Social media	12	Travel time	9

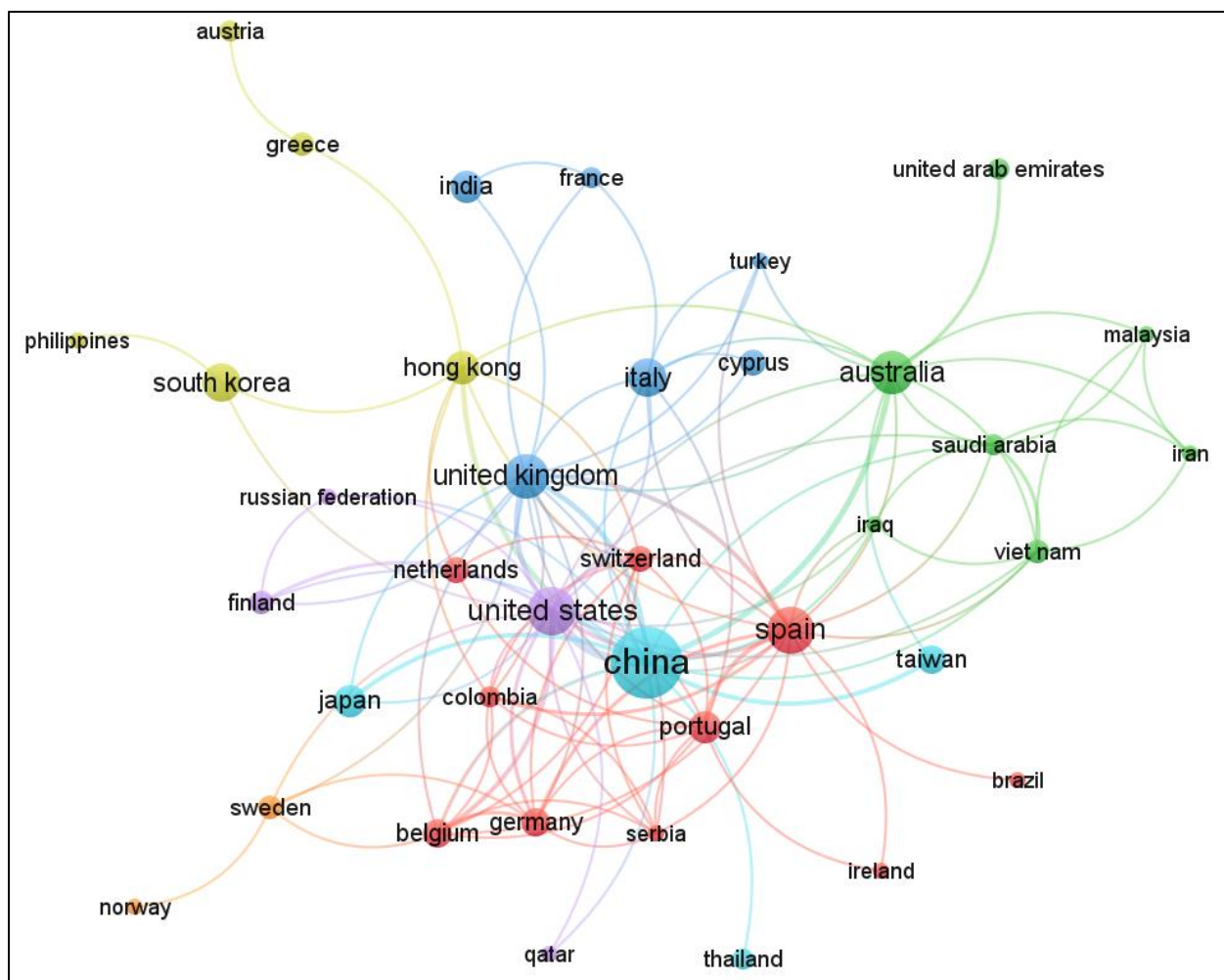
From the top keywords, it has been found that the keywords were distributed in three different fields, namely sustainability, tourism, and big data techniques.

The sustainability theme includes sustainable development, sustainability, environmental protection. Big data theme includes big data, data mining, data set, social media. Tourism theme includes China, ecotourism, tourism, public transport, travel behaviour, tourist destination, tourism management, urban area, urban transport, tourism development, travel time. The word cloud of keywords used in BDA in sustainable tourism is presented in Figure 5.









**Figure 7:** Country-author collaboration on writing articles selected for this study in BDA in sustainable tourism

Most collaborations are done among researchers from China, the USA, the United Kingdom, and Spain.

## 5 Discussion of the Findings

The study presents a literary analysis of the integration of BDA and sustainable tourism. In this regard, an SLR and bibliometric analysis of BDA and sustainable tourism were done, identifying 187 articles from the different databases. To begin SLR, articles, conference proceedings, and book chapters published from significant publishers like IEEE, Springer, Elsevier, etc., were considered. The shortlisted articles were systematically reviewed from different perspectives

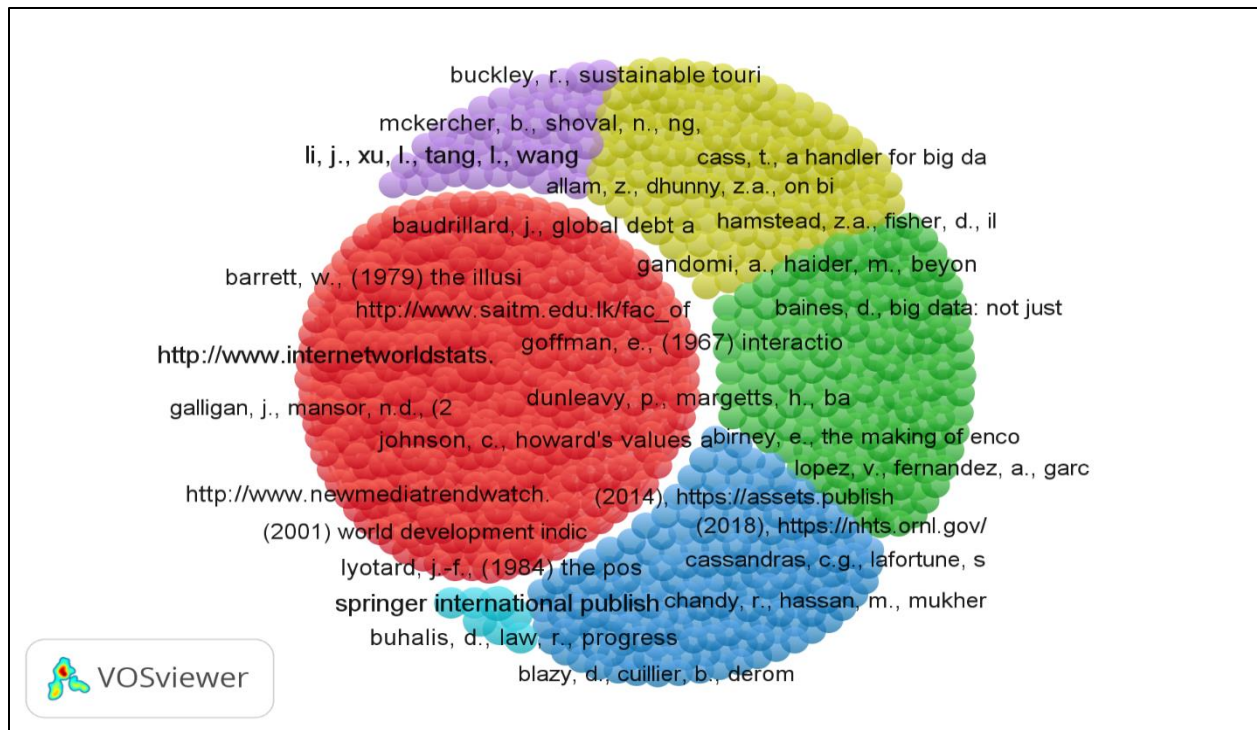
regarding BDA, such as sustainable hotel management, urban, regional, cultural and sustainable tourism, sustainable holiday trips and cycling, sustainable tourism transportation, sustainable travel behaviour, and social network and BDA in smart cities. Further, additional useful information on this integration research was extracted using bibliometric analysis. In this study, four major groups, i.e., document type, authors, countries, and word analysis was formed for bibliometric analysis. The top journals, influential organizations, leading authors and countries, and significant research trending were recognized. Top journals such as Sustainability (Switzerland), Advances in Intelligent Systems and Computing, IOP Conference Series: Earth and Environmental Science, ACM International Conference Proceeding Series, International Journal of Environmental Research and Public Health, ISPRS International Journal of Geo-Information, The Journal of Cleaner Production, The Journal of Sustainable Tourism and Sustainable Cities and Society were found in the domain of BDA and sustainable tourism. Moreover, the co-citation analysis in the area of BDA and sustainable tourism depicted top trending topics in the field of BDA in sustainable tourism are Tourism Globalisation and Sustainable Developments (Mossberger et al., 2013), Big Data in Hotel and Tourism Business (Chen et al., 2014), Sustainable Transportation in Tourism (Andersson et al., 2018), Cultural Heritage and Smart Cities (Bergen et al., 2019), Big Data in Tourism (Buckley, 2012; Edwards and Griffin, 2013; Fuchs et al. 2014; Nilbe et al., 2014; Li et al., 2018), and Tourism Management (Del Chiappa and Baggio, 2015; Encalada et al., 2017).

The top institutions researching big data and sustainable tourism integration are Beijing Normal University, Sun Yat-Sen University, Ton Duc Thang University, the University of Leipzig, and the University of Tokyo. The cluster analysis was carried out to realize the research network among authors. The perspectives of big data in tourism that have been explored in this literature review were sustainable hotel management, urban, regional, cultural and sustainable tourism, sustainable holiday trips and cycling habits, sustainable tourism transportation, sustainable travel behaviour, tourism through social network and smart cities (Line et al., 2020). The hotel management mainly focussed upon reducing fossil carbon footprints and implementing sustainability initiatives such as circular economy at the operational level. To grow the businesses, the hotel industries are working to improve their customer's experiences based on the BDA and develop eco-friendly properties (Brida et al., 2020). The urban, regional, cultural and sustainable tourism perspectives

provided insights on urban mobility and space utilization with the help of BDA (Lin et al., 2020). The circularity characteristics of urban tourism could be analyzed using big data generated from GPS technology. They could help us to understand better the relationships between travel, time, and distance circularity. The development of a universal parameter system on residential suitability was recommended. Sustainable holiday trips utilize BDA to help to ensure a high degree of satisfaction among tourists by enhancing their tourism experiences. The BDA can be used to help in addressing the tourism issues related to holiday trips. Regarding tourism transportation, it provides positive impacts on the country's economic benefits (Croes et al., 2021). If not handled properly, it can result in increased energy consumption. Thus, using BDA in tourism transportation can help to provide relatively more sustainable tourism experiences. The BDA applications were helpful in better understanding the tourist's behaviours, which can help service providers help the tourists select among residential options. The application of BDA of smart specialization of the dynamic tourism sector can improve the local and regional co-working within the diverse tourism dimensions. The data from the social networks can be used to predict tourists' interests which can help the providers more effectively coordinate within and among cities and regions. (Chun et al., 2020).

## **5.1 Cluster Analysis**

Cluster analysis shows the different categories of work being conducted in any particular field. Bibliographic coupling analysis was performed to identify different clusters of articles. It helps the researcher to identify different clusters of collaboration. In this review, six clusters were detected by analyses performed using VOS viewer, as presented in Figure 8. The articles from each cluster were reviewed, and a research theme was given to each cluster based on the articles in it. Cluster 1 (red) includes articles on tourism globalisation and sustainable development. Articles of cluster 2 (green) were based on big data in the hotel and tourism business. Cluster 3 (blue) includes articles on sustainable transportation in tourism. The articles in cluster 4 (yellow) discussed the role of big data in cultural heritage and smart cities. Cluster 5 (violet) includes articles on big data in tourism. Then finally, cluster 6 (light blue) includes articles on resilient tourism management. The discussion on each cluster and future research propositions were presented below sub-sections.



**Figure 8:** Cluster analysis of articles selected for this study in BDA in sustainable tourism

## 5.2 Emerging Research Themes

### 5.2.1 Cluster 1 (red): *Tourism Globalisation and Sustainable Development*

Current globalization has improved tourism activities (Chiu et al., 2021; Verma et al., 2022). As the internet enables users to find, analyze and shortlist their trips without involving travel agencies (Butler et al., 2021). De Oliveira Lima et al. (2018) performed studies on hotel sustainability using the systematic mapping approach. They found the main approaches used. Thirty-one per cent of author teams utilized data mining techniques, 55 per cent exclusively utilized machine learning methods, and 14 per cent of the works performed analysis using both techniques (Mossberger et al., 2013). Thus, highly significant contributions to the global economy are made through the tourism sector. But the sector also leads to many types of environmental impacts and creates pressures on local resources, which can negatively impact local and regional sustainability (Streimikiene et al., 2020). Thus, we propose the following propositions for future research:

- **Proposition 1:** Identifying and analysing the tourism strategies to be adopted in the tourism sector for sustainable development.

Successful adoption of sustainable tourism helps in establishing long-term collaborative initiatives amongst various stakeholders. For effective adoption of sustainable tourism, identification and analysing of its strategies are necessary. This would help in sustainable development within elements of tourism namely economic, social, and ecological.

- **Proposition 2:** The development of a sustainable framework for effective adoption of sustainable practices in the tourism sector.

The establishment of a comprehensive framework comprising barriers, challenges, principles, and motivation factors for effective adoption of sustainable practices in the tourism sector is necessary for ensuring sustainability.

- **Proposition 3:** Application of big data analytics to evaluate the environmental impacts of the tourism sector for sustainable development.

The potential negative effects of tourist development depend upon pressure on natural resources, physical impacts and, pollution which often include ecosystem deterioration. While the tourism industry impacts greenhouse gas emissions, the majority of which are produced from tourist transportation, it also suffers significant consequences from global warming. Such data could help in evaluating the environmental impacts of the tourism sector using big data analytics for sustainable development.

### ***5.2.2 Cluster 2 (green): Big Data in the Hotel and Tourism Business***

A critical aspect of sustainable tourism is hotel management to provide excellent tourism experiences for tourists (Grilli et al., 2021). Information technologies such as online hotel booking enhance hotel management efficiency (Chen et al., 2014). The previous studies revealed the importance of BDA approaches such as machine learning methods for analyzing the sustainability of hotels and travellers' behaviour (Vu et al., 2015). The industry practitioners utilized the BDA's learning to identify the critical attributes of satisfaction and positive experiences of tourism customers (Mariani and Borghi, 2021). Thus, we propose the following propositions for future research:

- **Proposition 4:** Use of big data analytics in predicting the tourist requirement, thereby enhancing tourism business.

One of the significant approaches to enhancing tourism business is understanding tourist requirements. Tourism experiences could be analysed using big data analytics to understand tourist behaviour that leads to sustainable tourism.

- **Proposition 5:** Assessing the challenges related to big data adoption in hotel management to develop the tourism business.

Examining challenges about big data adoption in hotel management helps in improving the tourism business. Some of the challenges include privacy and security issues, diverse data representation, storage and scalability issues etc.

- **Proposition 6:** Forecasting and monitoring of tourism business in hotel management using big data techniques.

Tourism generates huge data that may help in realizing forecast tourists expenses, tourist arrivals count and tourists profiles. Machine learning could be utilized to forecast and monitor tourism business in hotel management.

### ***5.2.3 Cluster 3 (blue): Sustainable Transportation in Tourism***

Tourism has positive impacts on the economy at the local, regional, and national levels (Chidakel et al., 2021). However, it also has negative impacts such as increases in energy consumption, and expansion of tourism can deteriorate the quality of the environment and increase impacts upon climate changes due to increased transportation-related fuel consumption (Xu et al., 2020). Tao et al. (2014) analysed the dynamics of bus transportation over different calendar days using BDA. They used the smart data card to analyse bus trip trajectories. The reviewed research findings can help develop and implement more intelligent bus trip systems for more sustainable transportation (Andersson et al., 2018). The BDA in sustainable tourism also contributed to the transportation network (Paiano et al., 2020). This will help industry practitioners analyse the dynamics of bus transportation and mobility of the transportation network by developing a smarter trip system for sustainable transportation. Thus, we propose the following propositions for future research:

- **Proposition 7:** To assess the environmental impacts of transportation networks using big data for efficient tourism.

Transportation networks' negative effects such as higher energy consumption and tourist expansion can degrade the ecosystem and exacerbate the effects of climate change owing to increasing transportation-related fuel consumption. These effects need to be assessed for sustainable transportation networks.

- **Proposition 8:** The development of a transportation model using BDA for sustainable transportation.

Development of a transportation model by using big data analytics techniques required for sustainable transportation. The transportation model may include sustainable strategies, planning requirements, operation principles, technology, financing etc.

- **Proposition 9:** Exploring the social and economic effects of sustainable transportation in tourism.

The social and economic effects of sustainable transportation in tourism need to explore. Social effects of sustainable transportation include conserving local culture and history, provision of social services, community building, revitalization of customs and art forms, commercialization of culture and art, and heritage preservation. Economic effects include public transportation investment that allows a variety of economic productivity and efficiency impacts to reveal as a result of changes in costs, travel times, and access factors, immediate effects of expenditure on public transportation, facilitating construction, manufacturing, and public transportation operation activities, and inferences concerning to policy consideration and interpretation of econometric data.

#### ***5.2.4 Cluster 4 (yellow): Role of big data in Cultural Heritage and Smart Cities***

Globalization has improved and increased tourism. Cities are becoming smart and are using information technologies to attract tourists (Gretzel and Koo, 2021). In this regard, Vilajosana et al. (2013) presented an approach to making cities smart by adopting BDA. The study reviewed the tourism business ecosystem and its stakeholders. They proposed an approach to scale up the business model. The authors also explored ICT technology applications to help make smarter and more sustainable cities (Chen et al., 2018; Bergen et al., 2019, Wondirad et al., 2020). Future work on the development of a universal parameter system on residential suitability was suggested. Thus, we propose the following propositions for future research:

- **Proposition 10:** Examining social media data using big data analytics techniques to promote cultural heritage.

To encourage cultural heritage, analysing social media data using big data analytics techniques would help in ensuring sustainability in tourism.

- **Proposition 11:** Exploring the visitor's movement patterns using big data analytics to understand the cultural attractions of the tourist.

The analysis of visitors' movement patterns using big data analytics can help city managers make tourist transportation-related improvements to help to ensure that they can enjoy the region's cultural attractions while not overwhelming their respective capacities.

- **Proposition 12:** Assessing IoT adoption challenges for establishing smart cities.

IoT adoption in developing cities helps in transforming into smart cities. Some of the challenges of IoT adoption include security and privacy concerns, interoperability problems, lack of proper infrastructure, social inclusion etc. These challenges need to be analysed using appropriate decision-making tools for smooth adoption of IoT in establishing smart cities.

### ***5.2.5 Cluster 5 (violet): Big Data in Tourism***

Serna et al. (2016) identified the sustainability issues on urban mobility in the user-generated content experiences and perceptions. The researchers developed important information about travel and activities and helped to improve the knowledge of urban mobility. The authors focus on the automatic identification of sustainable urban mobility, which helps progress toward more sustainable tourism. Environmental improvements in terms of noise pollution reduction should be implemented. Reductions in environmental emissions could increase the economic benefits of the tourism sector. Zhang et al. (2017) developed and used a method to create accurate protection positioning and historic district utilization using BDA. The authors identified the issues that existed in historic district developments designed to protect the historical sites to contribute to sustainable and healthy protection and maintenance of culturally rich locations (Buckley, 2012; Edwards and Griffin, 2013; Fuchs et al. 2014; Nilbe et al., 2014; Li et al., 2018). The linkage between BDA and sustainable tourism could be expanded by utilizing the IoT and data mining tools in the tourism industry. Additionally, a predictive model could be developed by tourism leaders to better understand the sentiments of social networks that can be used to obtain extensive data on tourists' wishes, perceptions, and recommendations for improvements (Sohrabi et al., 2020). Thus, we propose the following propositions for future research:

- **Proposition 13:** Identifying and analysing the big data adoption strategies to predict tourist behaviour.



Big data created by tourism has suggested various opportunities for decision-makers to gain greater insights. Nevertheless, research on big data analytics has proved the support for tactical decision-making. Thus, identification and analysis of big data adoption strategies are necessary to predict tourist behaviour.

- **Proposition 14:** Developing a predictive model for tourist leaders to understand the perceptions and recommendations of tourists using big data analytics.

A predictive model for tourist organizers comprising tourist recommendations and perceptions of tourism needs to establish using big data analytics to facilitate sustainable tourism. A big data analytics approach in aiding destination management organisations in analysing and forecasting visitor behaviour trends at specific places.

- **Proposition 15:** Establishing a socio-economic-environment machine learning-based model for identifying low-cost and sustainable culturally rich locations.

The development of a socio-economic-environment machine learning-based model helps in recognizing sustainable culturally rich locations at low cost.

#### ***5.2.6 Cluster 6 (light blue): Resilient Tourism Management***

Encalada et al. (2017) discussed the importance of information and communication technologies by leaders of smart tourism destinations. A novel framework was proposed by Gwak et al. (2017) for optimal location selections for green roofs to help to enhance the quality of life of urban ecosystems. The authors considered honeybee habitats together with environmental and socio-economic effects while making location selections. (Del Chiappa and Baggio, 2015; Encalada et al., 2017). The research on BDA and sustainable tourism has enormous implications for the roles of BDA in significant addressing challenges related to consumer behaviour in tourism management. The IoT and data mining tools can be effectively utilized for improving sustainability in tourism management. Thus, we propose the following propositions for future research:

- **Proposition 16:** Exploring the applications of intelligent technologies in tourism management.

Discovering the intelligent technologies applications in tourism management helps in improving sustainability in tourism management.

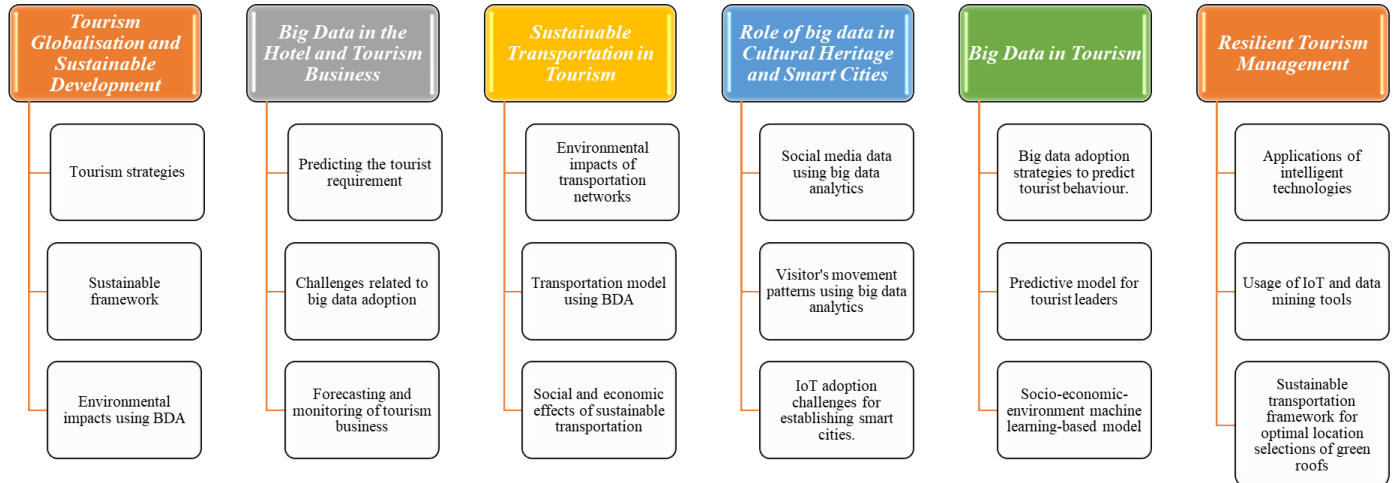
- **Proposition 17:** Discovering the usage of IoT and data mining tools for improving sustainability in tourism management.

The usage of data mining tools and IoT has helped tourism leaders to develop a new dimension of sustainable tourism. IoT and data mining tools help in tackling global impact and climate change concerns by monitoring travel, energy consumption, location information, maintenance etc.

- **Proposition 18:** The development of a sustainable transportation framework for optimal location selections of green roofs to improve the quality of life of urban ecosystems.

To improve the quality of life of urban ecosystems establishment of sustainable transportation is necessary for optimal location selections of green roofs. The ability for improving green-roof operation by better understanding the connections between its ecosystem elements, particularly those between soil biota, growth media, and plants, as well as those between community structure and ecosystem functioning facilitates sustainable transportation.

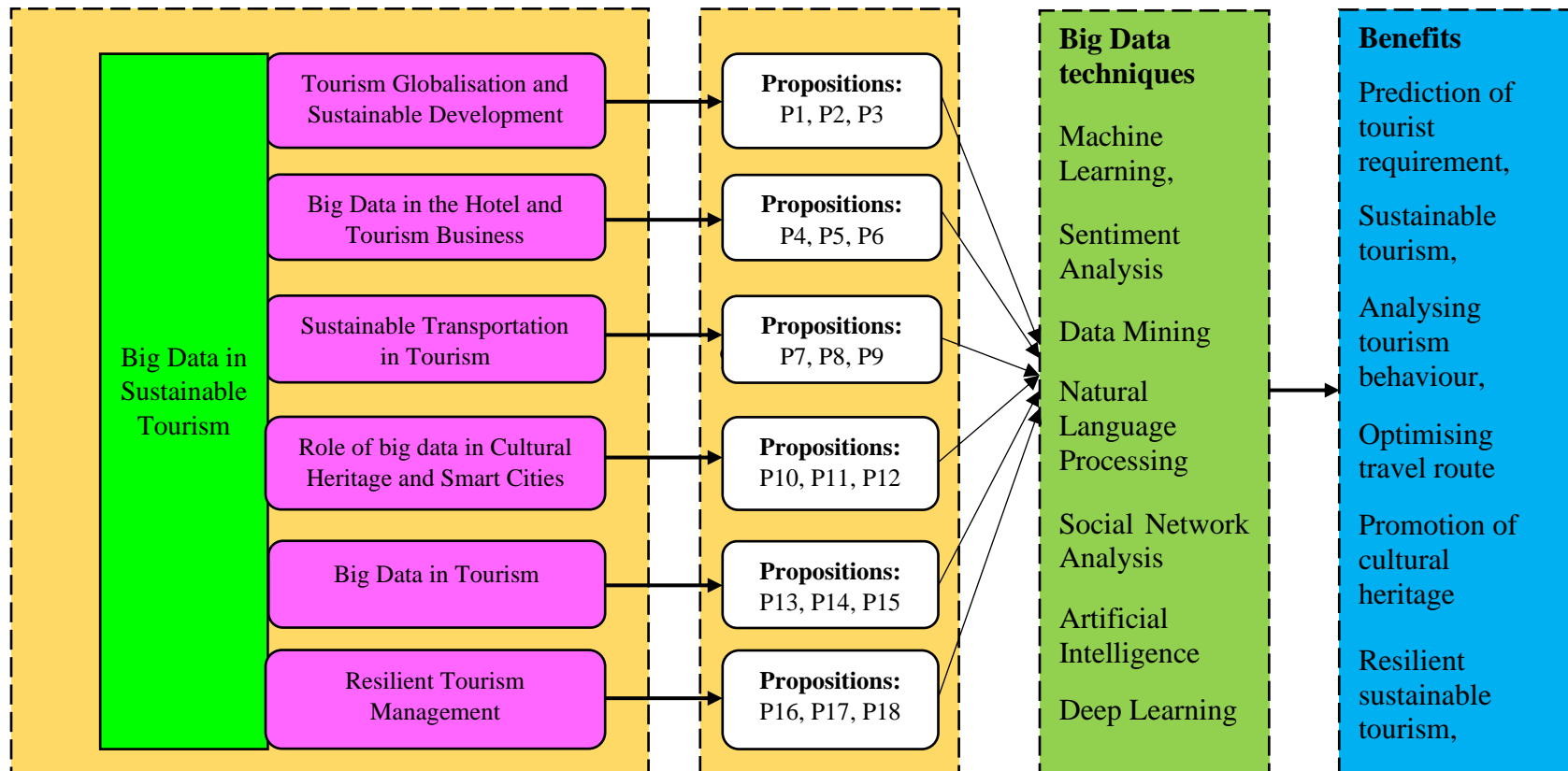
Based on the review, a theoretical model has been proposed depicting propositions as shown in Figure 9.



**Figure 9:** Theoretical model presenting the key proposition in the area of BDA in tourism

### 5.3 The Proposed Framework for Integration of BDA in Sustainable Tourism

Figure 10 shows the proposed framework for utilizing BDA in tourism to improve their offerings' relative sustainability and tourist experiences.



**Figure 10:** The research framework for the increasing roles of BDA in seeking to achieve relatively more sustainable tourism offerings and tourist experiences

The proposed model has been developed to enhance customer satisfaction in the tourism sector utilizing BDA. Further, access to sustainability with the help of BDA in tourism is presented. The discussion on BDA application in sustainable tourism had been done in previous studies, and with the help of these studies, the model has been constructed (Paiano et al., 2020). The model focuses on analysing the tourism sector and the critical attributes related to it.

### ***5.3.1 Identification of tourism sector***

The tourism industry consists of various sectors, including transportation, accommodations, food and beverages, entertainment, and connected industries. Initially, the case sector needs to be selected for the analysis to move towards relatively more sustainable tourism. To make such progress in the tourism sector, organizations need to define the culture, customer behaviour, and the extent of facilities they provide.

### ***5.3.2 Identification of key attributes***

Identification of critical attributes related to satisfaction and customer experiences in the tourism sector can use the online survey. The proposed approach would help gather Big unstructured data to analyze tourists' expectations of the tourism sector. Ban et al. (2019) investigated key attributes of satisfaction and experiences of hotel customers using online surveys. A total of 6596 hotel responses were gathered and were assessed using frequency analysis to rank the frequency of cited attributes. To understand the satisfaction and experiences of hotel customers, tools such as factor analysis, semantic network analysis, and regression analysis were utilized. The findings showed that keywords such as Food and Beverages, hotel staff, service, care, etc., were prominent customer satisfaction indicators. Tang (2020) analyzed the 63 service-oriented tourist cities in China and highlighted the geographical gaps encountered by networks in urban tourism. The author used BDA for developing the regional linkage of 38 tourism organizations in the cities. The findings revealed the differences between geographical distribution and connectivity from the analyzed data showing hierarchical tendencies and regional pattern characteristics of cities in the network.

### ***5.3.3 Identification of BDA methods for analysis***

In this stage, the gathered data from the tourism sector were analysed using BDA methods such as machine learning, random forest classifiers, predictive modelling, cluster analysis, and Natural

Language Processing (NLP). The analyses help predict human behaviour with the relative sustainability of the organization and their satisfaction with the tourist's experiences.

#### ***5.3.4 A move towards sustainability***

Finally, advanced tourism service-providing organizations become involved in developing performance indicators to measure the progress of the sustainable tourism services they provide (Taboada and Han, 2020). Moreover, achievable and small targets should be planned when they prioritize their organizational sustainability contributing activities.

The proposed framework can help sustainable tourism providers move more rapidly and consistently towards sustainable tourism by using BDA. Additionally, the challenges in adopting the BDA in tourism may exist, which need to be discussed before accepting the proposed framework. The required attributes must be clearly defined and may include readiness factors, satisfaction criteria, drivers, or barriers to BDA in sustainable tourism. In addition to this, the different tourism sectors may face difficulties implementing the proposed framework due to a lack of technical knowledge of sustainability and usage of BDA.

### **5.4 Implications of this bibliometric and network analysis**

#### ***5.4.1 Contribution to the literature***

The present study contributed to the literature by deriving extensive findings in the field of the tourism sector. The BDA approaches help to improve transportation networks and thereby enhance the sustainability of the tourism networks. This will help industry practitioners to analyse the dynamics of transportation networks by developing smarter trip systems that contribute toward transitioning to sustainable transportation. The consumer's complaints can be easily assessed and responded to by using big data technologies. The review helped in better understanding how data mining tools can be beneficial for developing novel experiences for tourists within sustainable tourism. The Bibliometric study examined key contributions in the field of BDA in sustainable tourism made by researchers, institutions, journals, diverse sources, and countries. Further, the network analysis provided insight into the collaboration network among authors and nations conducting BDA research in sustainable tourism. The bibliometric study and the network study helped in analysing the evolution and trends in BDA research in sustainable tourism. This study

offered a research framework to support future research to assist travellers, the tourism sector, travel, hotel, and broader hospitality service providers in understanding the benefits of implementing BDA in making progress toward more sustainable tourism.

#### ***5.4.2 Implications for Practice***

The tourism sector can utilize the findings of the study in improving the operations of the industry. Further, the insights developed from the analysis will help in smoothing the decision-making process. The BDA in tourism can efficiently handle the experiences of tourists and offers customized offers as per their needs. Industry practitioners and researchers can use the BDA for improving the tourist's experiences based using machine learning techniques. Usage of BDA and complimentary AI tools can help municipal leaders and tourism service providers co-work to plan and implement smarter transportation networks designed to reduce transportation's environmental impacts. This paper effectively documented the importance of BDA approaches such as machine learning methods for analysing hotels' sustainability and tourist expectations and behaviour. The practitioners can utilize the learning from the big data in tourism research for identifying the key attributes related to the satisfaction and positive experiences of tourists. Moreover, the BDA facilitates tourism service providers to understand better and manage the sustainability issues on urban mobility, travel circularity, and residential suitability. The traveller trends can be analysed using Big Data analytics by generating a specific marketing strategy for the target demographic and gathering information from various consumer centres. Big Data technologies like cloud-based analytics and Hadoop give vast data storage capacity and provide structured information gathered from a variety of sources. For instance, airline operators can utilize big data to realize not only passenger behaviour and travel preferences but also the overall operation of the sector. This review provides an understanding of big data's significance in the tourism sector and thus big data assists airline operators with strategic pricing and revenue management, allowing them to expand their income prospects while providing the finest travel experiences to travellers.

#### ***5.4.3 Managerial and Research Implications***

This article reviewed the results of the usage of BDA in sustainable tourism. The selected articles were reviewed from diverse perspectives of sustainable tourism: sustainable hotel management, urban, regional, cultural and sustainable tourism, sustainable holiday trips and cycling habit, sustainable tourism transportation, sustainable travel behaviour, social network, and BDA in smart

cities. The critical lessons documented can help tourism services providers adopt BDA in the tourism sector to help them provide more sustainable tourism services for the tourists and all 'at large'. The findings can help managers plan and conduct practical training for their employees concerning BDA in sustainable tourism. For researchers in the field of sustainable tourism, new insights were developed from the review on the development and implementation of suitable mechanisms for collecting and analysing the Big data related to sustainable tourism and establishing an analytical and conceptual framework for building upon the advantages, principles, applications and critical performance dimensions of Big data with the sustainable tourism. In addition, the authors investigated the tourism services providers' readiness for using Big data to support sustainable tourism approaches to improve the tourism industry's social, environmental, and economic performance. Some early adopters are using BDA tools, but many have not yet begun to use them. The tourism sector leaders, globally, should provide short online courses to help tourism service providers become familiar with and help them learn how to use these new tools to help them provide better and more sustainable tourism services that are also more ecologically sustainable.

### **5.5 Unique Contributions of this Literature Review**

The unique contribution of this study was the systematic literature review along with bibliometric analyses of articles on the BDA and sustainable tourism. This review sought to better understand the inter-relationships between BDA and tourism in the context of sustainability. This SLR of articles related to the integration of BDA in helping to improve sustainable tourism from diverse perspectives such as sustainable hotel management, urban, regional, cultural and sustainable tourism, sustainable holiday trips, cycling, sustainable tourism transportation, sustainable travel behaviour, and social networks and BDA in smart cities. This study reviewed the benefits of using BDA to transform regular tourism into relatively more 'sustainable tourism.' The review helps in identifying BDA applications in different tourism sub-sectors such as transportation, hotels, restaurants, cultural heritage, water-based recreation, etc.

## **6. Conclusions**

The increases in interest in tourism globally have increasingly raised concerns about the negative impacts of tourism on natural resource management. Therefore, there is an urgent need to

implement sustainable tourism to help societies and tourists co-work and co-enjoy sustainable tourism, which manages sustainable, circular economies. This can be partially achieved by reducing excess transportation and consumption by using new information technology tools. Recent studies revealed the benefits of BDA to help tourism services providers to co-work with political leaders to ensure that there is a systematic transition to providing more sustainable tourism in transportation and in all other dimensions of providing tourists safe, enjoyable experiences and positive memories.

This review sought to fill the gap in knowledge about the benefits of implementing BDA within the tourism industry to help them provide more sustainable tourism services. The authors performed a systematic literature review, bibliometric analyses, and network analyses of 187 articles on the BDA and sustainable tourism.

The review helps in understanding the inter-relationships between BDA and tourism in sustainability. The SLR of articles related to BDA in sustainable tourism focussed upon various perspectives such as sustainable hotel management, urban, regional, cultural and sustainable tourism, sustainable holiday trips and cycling habit, sustainable tourism transportation, sustainable travel behaviour, and social network and BDA in smart cities.

This study concluded that accelerated progress toward planning and providing more sustainable tourism experiences could be achieved by using tools such as BDA, IoT, and data mining tools within tourism systems. Usage of these tools can help the tourism industry better anticipate and meet the needs and wishes of the tourists for safe and sustainable experiences that are socially, ecologically, and economically sustainable in the short and long-term future.

This article highlighted the benefits of the integration of BDA in the sustainable tourism sector. The adoption of BDA in tourism management can be increasingly beneficial for the suppliers and tourists because the management can interactively obtain and build upon tourists' feedback regarding satisfaction with their experiences and obtain suggestions for improvements that should be made. Implementation of BDA can help tourism service providers and political leaders to co-work with the tourists to provide positive benefits for the tourism industry as well as for the broader horizons of smart cities to help to preserve the local and regional culture and to facilitate development and support for sustainable, smart and connected communities. The positive linkages between BDA and sustainable tourism can be expanded by utilising the IoT and other data mining tools. Also, a predictive model could be developed to understand tourists' sentiments better as



reflected in their interactions on social networks, which can be used to improve data gathering on tourists' wishes, perceptions, and recommendations for improvements. The present work contributed to analysing the big data-related research in sustainable tourism for understanding the significance of BDA using a systematic literature review. The study proposed a research framework that depicts the increasing roles of BDA in seeking to achieve relatively more sustainable tourism offerings and tourist experiences. The proposed framework helped to enhance customer satisfaction in the tourism sector utilizing BDA. Further, access to sustainability with the help of BDA in tourism is presented. The discussion on BDA application in sustainable tourism had been done in previous studies, and with the help of these studies, the model has been constructed. The model focuses on analysing the tourism sector and the critical attributes related to it.

However, in the future, concrete work signifying the BDA applications in sustainable tourism where information about technics or epistemology that tourism scholars have applied can be considered for analysis. Moreover, the researchers can utilize the proposed framework for performing further analysis.

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