Tourism eco-efficiency: Progress and prospect

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ABSTRACT

This study aims to analyse relevant literature on tourism eco-efficiency which has arrived since this terminology was proposed almost two decades ago. This study was conducted using bibliometric analysis based on literature findings from the Scopus database, filtered by the ROSES framework, which resulted in a collection of 99 articles between 2005 and 2023, further analysed using the Biblioshiny package in R. We conducted five analyses, including general and source-based – to explore the most relevant and impactful journals, author-based – to highlight the most frequently cited productive researchers, and country-based – to identify those with consistent research networks and an abundant output on related topics. Additionally, there was keyword-based – emphasizing the evolution of tourism eco-efficiency discourse over time. This keyword-based analysis is further divided into factorial – clustered keywords; and thematic – grouping keywords into quadrants offering retrospective insight and identifying unexplored topics for future research. The findings of this study propose valuable insights into the topic of tourism eco-efficiency and propose further research directions, including those on spatial analysis, tourism spillover effects, integration with environmental regulations and interdisciplinary collaborations.

KEYWORDS

tourism eco-efficiency, bibliometrics analysis, systematic review

1. Introduction

Global tourism activities have significantly increased during the past seventy years. The United Nations World Tourism Organization (UNWTO, 2025), stated that the number of international tourists has increased significantly from 25.2 million per year in the 1950s to 1.46 billion in 2019, while the World Bank Group (2019) reports an increase in numbers from 1.08 billion per year in 1995 to 2.4 billion in 2019. It is undeniable that the far-reaching impact of tourism encompasses environmental sustainability, profoundly manifested through emissions and ecological footprints.

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The intensifying global tourism industry is expected to generate up to 8% of global greenhouse gas (GHG) output (Lenzen et al., 2018). This harmful trend adversely affects air quality, deterring tourist inflow into host countries and nearby regions (Su & Lee, 2022), while simultaneously worsening the ecological footprint in tourist-destination countries. An alarming revelation about the environmental impact is shown while examining the top ten countries with the highest number of international tourist arrivals (Li et al., 2022; Nathaniel et al., 2021), it highlights the negative consequences of global tourism activities. Furthermore, global tourism activities also contribute significantly to solid waste generation (Zambrano-Monserrate et al., 2021), its footprint produced by global tourism activities is approximately 11.2 billion tonnes per year, which contributes to 5% of global greenhouse gas emissions (United Nations Environment Programme, n.d.). Consequently, global attention toward tourism that prioritizes a balance between social, economic and environmental dimensions – commonly referred to as sustainable tourism – continues to grow. As a concept, sustainable tourism does not stand on its own; it is intertwined with other relevant terminologies, such as ecotourism (Prerana et al., 2024), green tourism, blue tourism, circular tourism (Niñerola et al., 2019), and even recently, the emerging framework of regenerative tourism (Bellato et al., 2022). Amidst the variance of sustainable tourism derivative terms, one topic that receives significant focus is tourism eco-efficiency.

As a concept, tourism eco-efficiency is initially based on environmental efficiency as proposed by Freeman et al. (1973) and emphasized further by Schaltegger and Sturm (1990) as ecological efficiency or eco-efficiency. It was then defined by the World Business Council for Sustainable Development (2000, p. 3) as "providing goods and services at competitive prices to fulfil human needs and improve quality of life while striving to minimize ecological impact and resource use following the Earth's carrying capacity". Tourism eco-efficiency as a phrase or term, on the other hand, was coined by Gössling et al. (2005), based on a viewpoint that aims to balance economics and an environment that operates from macro to micro levels (Yang et al., 2008) focusing on an array of composite indicators. It suggests a method to improve the effectiveness of utilizing natural resources for economic purposes (Kytzia et al., 2011), including utilization of energy, water and other material expenses as input with their inherent consequences and externalities on the environment, both natural and built (Kelly & Williams, 2007), and in supply chain interactions (Xia et al., 2022*)*.

This study aims to analyse the idea of tourism eco-efficiency which was established in 2005 aiming to include bibliometric analysis procedures as methods used in the process and further the comprehensive review of the results. It will then provide a detailed understanding of the present research landscape on tourism eco-efficiency and pinpoint promising areas for future research.

2. Data and methods

The work employs bibliometric analysis. A thorough search of the Scopus database was conducted, following a process aligned with the reporting standards for systematic evidence syntheses (ROSES), recommended by Haddaway et al. (2018) designed for reviews in conservation and environmental management using bibliometric analysis. This is executed through a comprehensive performance evaluation and mapping procedure (Donthu et al., 2021), facilitated by the adept utilization of Bibliometrix (Aria & Cuccurullo, 2017), an R-based package known for its flexibility and robustness, surpassing its counterpart, Vosviewer, in performance evaluation and mapping procedures (Arruda et al., 2022). Biblioshiny, an extension of
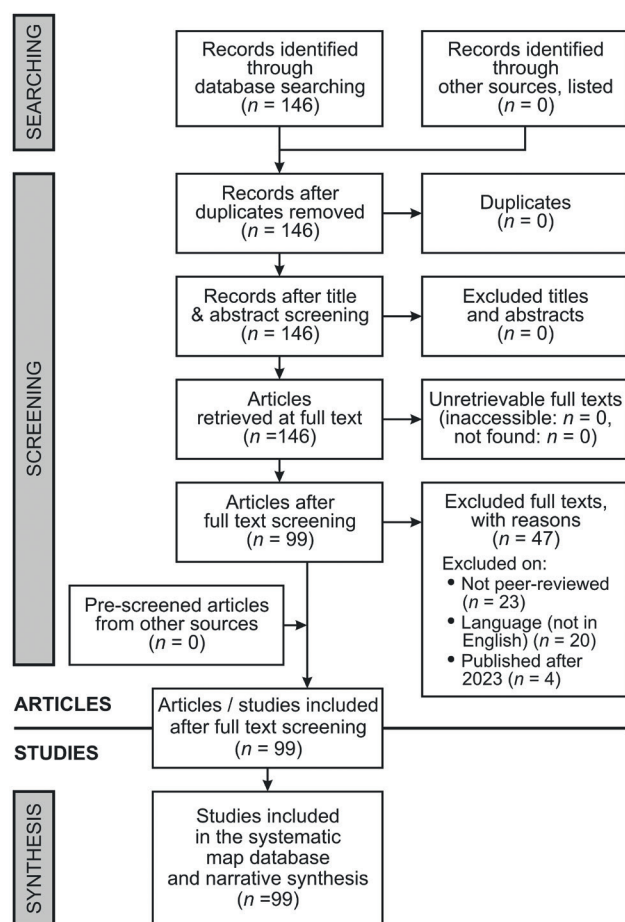

Figure 1. Location of Sarawak
Source: authors

Bibliometrix, stands out for its user-friendly interface and ability to create several visualization formats, providing helpful insights for further study (Moral-Muñoz et al., 2020).

An extensive search was carried out on the Scopus database focusing on titles, abstracts and keywords employing the following search criteria: tourism AND eco-efficient*, OR ecoefficient*, OR "ecological efficient*". The search resulted in a total of 146 publications, including 125 peer-reviewed articles, 11 conference proceedings, five books, and five book series. Subsequent refinement of the dataset filters it down to peer-reviewed articles that were published before 2024. Furthermore, the articles published were also reduced to only those in English and excluded articles in Chinese (19), Finnish (1) and Spanish (1). After screening, 99 peer-reviewed articles then went undergo rigorous bibliometric analysis. The filtering and article selection process is carefully guided by the ROSES flow diagram was for systematic maps (Haddaway et al., 2017), as depicted in the following Figure 1.

3. Results and discussion

3.1. General findings

The analysis of 99 publications using Biblioshiny revealed that they were sourced from 52 journals and collectively they produced 3995 citations, averaging 40.35 citations per article. The general findings also suggest that the typical article has a publication age of about five years and in this time there has been a notable rise in publications focusing on tourism eco-efficiency. Figure 2 illustrates this increase, with the number of articles published after 2019 surpassing the average annual publication rate of previous periods. Some even had zero between 2009 and 2015. The general findings also indicate that together all papers employed a substantial number of references, totalling 4956. Keywords plus (ID)-based keywords come to 573, much surpassing author's keywords (DE) which totalled 329. Furthermore, out of 277 authors who contributed to the publications, only nine were single authors, while the remaining 268 collaborated in groups to write the other 90, with an average of 3.7 co-authors for each. The engagement in collaborative writing, however, is not matched by opportunities for international cooperation among authors, with only 22.5% of international co-authorship taking place throughout the analysis period of the 99 papers discussed. The general findings are shown in Table 1 and Figure 2.

Table 1. General findings on articles selection

Main information	
Timespan	2005–2023
Sources (journals)	52
Articles	99
Annual growth rate (%)	18.11
Articles average age	5.16
Total citations	3995
Average citations per article	40.35
References	4956
Keywords plus (ID)	573
Author's keywords (DE)	329
Authors	277
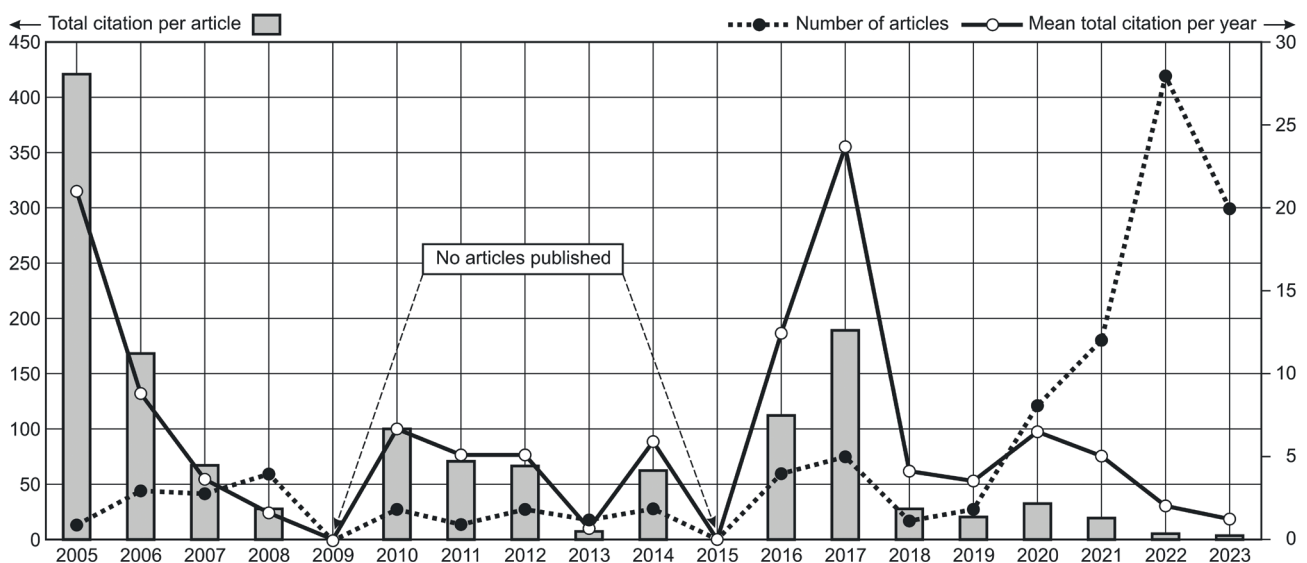
Figure 2. Articles and citations
Source: authors

Table 1 (cont.)

Main information	
Single-authored articles	9
Multiple authors articles	90
Co-authors per articles	3.74
International co-authorships (%)	22.5

Source: authors.

3.2. SOURCE-BASED ANALYSIS

The 99 articles were sourced from a total of 52 publications. Specifically, 36 originated from a single journal source, while the remaining 63 were distributed among 16 different sources. Figure 3 displays Bradford's law framework (Bradford, 1934), categorizing the 52 current journal sources into three zones (Brookes, 1969; Shenton & Hay-Gibson, 2009). Zone 1, referred to as core sources, consists of five journals; zone 2, known as the intermediate domain, includes 15 journals, four of which published only one article; zone 3 includes 32 journals, each of which produced only one article. Table 2 provides a list of journals categorized under the three zones, including the publishers' origin and the number published during the period of analysis. Elsevier is the leading publisher with 15 journals contributing a total of 28 articles while MDPI follows closely, with six journals publishing 26 articles on average in the past two years.

The classification carried out according to Bradford's law is only decided by the number of articles and does not represent relevancies or impacts. Analysis from Biblioshiny also assesses the relevance of journal sources by considering the number of articles per source journal, while the impact is evaluated using the citations number from the source journals and the average number of citations per article in that journal.

Table 3 shows the 15 journal sources with the highest number of articles that correlate with Bradford's law, all of which fall into zones 1 and 2. On the other hand, Table 4 presents the impact of 15 articles, however, this does not strictly align with Bradford's law due to variations in the number of source journals from different zones and the inconsistent correlation between the number of articles produced by each source journal and their impact based on citations. This is shown by the numbers in zone 1 (two source journals) and zone 2 (five), compared to those from zone 3 (eight). We highlight six journal sources in the Table 3 and Table 4 with shared categorize as relevant and important, including *Ecological Economics*, *Journal of Cleaner Production*, *Journal of Sustainable Tourism*, *Tourism Management*, *Waste Management* and *Current Issues in Tourism*.
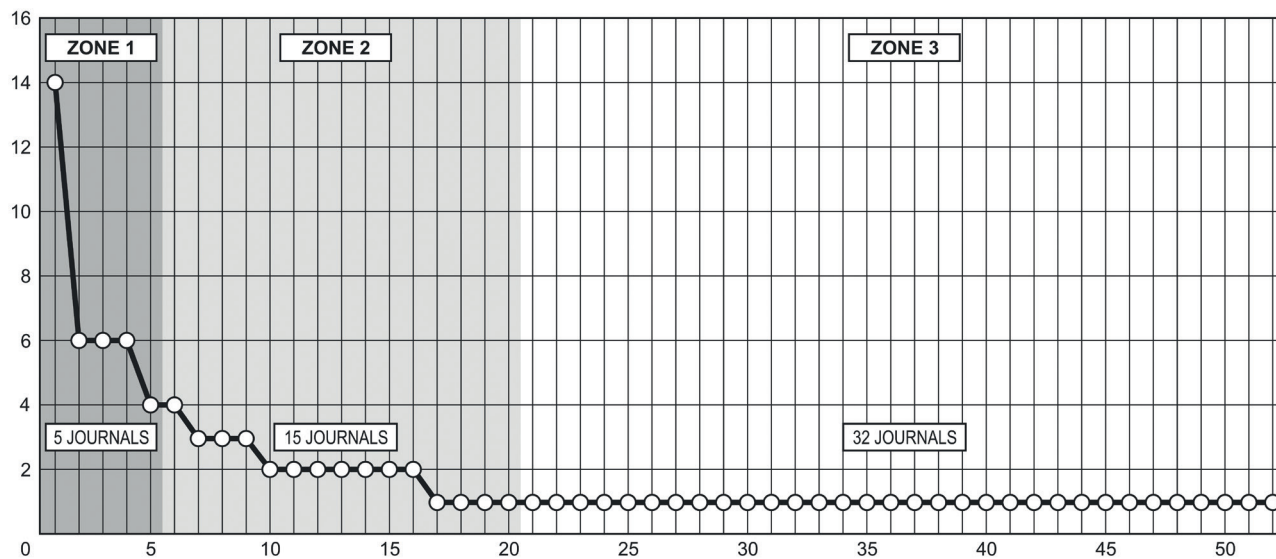

Figure 3. Bradford's law
Source: authors

Table 2. List of sources based on Bradford's law

Rank	Sources	Publishers	Articles published	Zone
1	*Sustainability*	MDPI	14	1
2	*International Journal of Environmental Research and Public Health*	MDPI	6	
3	*Journal of Cleaner Production*	Elsevier	6	
4	*Tourism Management*	Elsevier	6	
5	*Journal of Environmental Management and Tourism*	ASERS	4	

6	*Journal of Sustainable Tourism*	Taylor & Francis	4	2
7	*Environmental Science and Pollution Research*	Springer	3	
8	*Forests*	MDPI	3	
9	*Frontiers in Environmental Science*	Frontiers	3	
10	*Current Issues in Tourism*	Taylor & Francis	2	
11	*Ecological Economics*	Elsevier	2	
12	*Environment, Development and Sustainability*	Springer	2	
13	*Journal of Environmental Management*	Elsevier	2	
14	*Journal of Environmental Protection and Ecology*	Scibulcom	2	
15	*Waste Management*	Elsevier	2	
16	*Waste Management and Research*	SAGE	2	
17	*Acta Ecologica Sinica* (now *Ecological Frontiers*)	Elsevier	1	
18	*Applied Ecology and Environmental Research*	ALÖKI Institute	1	
19	*Arabian Journal of Geosciences*	Springer	1	
20	*Clean Technologies and Environmental Policy*	Springer	1	
21	*Ecological Informatics*	Elsevier	1	3
22	*Economies*	MDPI	1	
23	*Energies*	MDPI	1	
24	*Engineering Reports*	Wiley	1	
25	*Environmental Impact Assessment Review*	Elsevier	1	
26	*Environmental Monitoring and Assessment*	Springer	1	
27	*Environmental Science and Policy*	Elsevier	1	
28	*Frontiers in Public Health*	Frontiers	1	
29	*International Journal of Low-Carbon Technologies*	Oxford University Press	1	
30	*International Journal of Services, Technology and Management*	Inderscience	1	
31	*International Journal of Sustainable Engineering*	Taylor & Francis	1	
32	*Journal of Coastal Research*	BioOne	1	
33	*Journal of Environmental Assessment Policy and Management*	World Scientific	1	
34	*Journal of Hospitality and Leisure Marketing*	Taylor & Francis	1	
35	*Journal of Travel Research*	SAGE	1	
36	*Land*	MDPI	1	
37	*Landscape and Urban Planning*	Elsevier	1	
38	*Leisure/Loisir*	Taylor & Francis	1	
39	*Mathematical Problems in Engineering*	Hindawi	1	
40	*Ocean and Coastal Management*	Elsevier	1	
41	*PLoS ONE*	PLOS	1	
42	*Portuguese Economic Journal*	Springer	1	
43	*Research in Transportation Economics*	Elsevier	1	
44	*Scientific Programming*	Hindawi	1	
45	*Scientific Reports*	Nature	1	
46	*Social Responsibility Journal*	Emerald	1	
47	*Socio-Economic Planning Sciences*	Elsevier	1	
48	*Sustainable Development*	Wiley	1	
49	*Tourism Economics*	SAGE	1	
50	*Tourism Planning and Development*	Taylor & Francis	1	
51	*Travel Behaviour and Society*	Elsevier	1	
52	*Urban Forestry and Urban Greening*	Elsevier	1	

Source: authors.

Table 3. Most relevant sources

No.	Sources	Articles published	Citations	Impact (citations per article)	Zone	Publisher
1.	*Sustainability*	14	188	13.43	Zone 1	MDPI
2.	***Journal of Cleaner Production***	6	1044	174.00	Zone 1	Elsevier
3.	***Tourism Management***	6	548	91.33	Zone 1	Elsevier
4.	*International Journal of Environmental Research and Public Health*	6	47	7.83	Zone 1	MDPI
5.	***Journal of Sustainable Tourism***	4	554	138.50	Zone 2	Taylor & Francis
6.	*Journal of Environmental Management and Tourism*	4	4	1.00	Zone 1	ASERS
7.	*Environmental Science and Pollution Research*	3	75	25.00	Zone 2	Springer
8.	*Forests*	3	16	5.33	Zone 2	MDPI
9.	*Frontiers in Environmental Science*	3	16	5.33	Zone 2	Frontiers
10.	***Ecological Economics***	2	436	218.00	Zone 2	Elsevier
11.	***Waste Management***	2	76	38.00	Zone 2	Elsevier
12.	***Current Issues in Tourism***	2	67	33.50	Zone 2	Taylor & Francis
13.	*Journal of Environmental Management*	2	32	16.00	Zone 2	Elsevier
14.	*Waste Management and Research*	2	7	3.50	Zone 2	SAGE
15.	*Environment, Development and Sustainability*	2	7	3.50	Zone 2	Springer

Note: highlighted in bold are six journals with most articles published and highest citations per article.
Source: authors.

Table 4. Most impactful source

No.	Sources	Impact (citations per article)	Citations	Articles published	Zone	Publisher
1.	***Ecological Economics***	218.00	436	2	Zone 2	Elsevier
2.	***Journal of Cleaner Production***	174.00	1044	6	Zone 1	Elsevier
3.	*Environmental Science and Policy*	161.00	161	1	Zone 3	Elsevier
4.	***Journal of Sustainable Tourism***	138.50	554	4	Zone 2	Taylor & Francis
5.	*Ocean and Coastal Management*	130.00	130	1	Zone 3	Elsevier
6.	***Tourism Management***	91.33	548	6	Zone 1	Elsevier
7.	*Environmental Impact Assessment Review*	91.00	91	1	Zone 3	Elsevier
8.	*Landscape and Urban Planning*	79.00	79	1	Zone 3	Elsevier
9.	*Acta Ecologica Sinica* (now *Ecological Frontiers*)	49.00	49	1	Zone 2	Elsevier
10.	*Journal of Travel Research*	49.00	49	1	Zone 3	SAGE
11.	*Research in Transportation Economics*	43.00	43	1	Zone 3	Elsevier
12.	***Waste Management***	38.00	76	2	Zone 2	Elsevier
13.	***Current Issues in Tourism***	33.50	67	2	Zone 2	Taylor & Francis
14.	*Socio-Economic Planning Sciences*	29.00	29	1	Zone 3	Elsevier
15.	*Journal of Coastal Research*	29.00	29	1	Zone 3	BioOne

Note: highlighted in bold are six journals with highest citations per article and most articles published.
Source: authors.

3.3. Author-based analysis

The articles were analysed for their impact by examining citations, which are categorized as local or global. Local citations refer to the number that a specific article received from the 98 others included in the analysis. Global citations, on the other hand, refer to the total number received by an individual article. What makes this analysis intriguing is that there is overlap between the two groups from both a local and a global viewpoint, as well as contrasting pieces. This indicates that content has a high number of global citations but very few, or even no, local citations. These citations are not displayed appropriately in Biblioshiny when analysing data using the most recent database, as opposed to the older one. We conducted data scraping from the list of 4956 co-citation references and performed the calculations individually.

The results are shown in Table 5 and Table 6. Table 5 displays 15 articles with the highest number of global citations, ranging from 79 to 600 indicating that four focusing on the global issue but have very few mentions in local contexts: D'Amato et al. (2017), Scheepens et al. (2016), Lynes and Dredge (2006) and García-Melón et al. (2012). The article by D'Amato et al. (2017) briefly touches on eco-efficiency in tourism, highlighting its criticisms of consumption incentives and promoting regenerative solutions within a circular economy and bioeconomic frameworks. The connections between eco-efficiency in tourism and its relationship with the notion of the circular economy were also discussed by Scheepens et al. (2016) in their study on water-based tourism. Lynes and Dredge (2006) and García-Melón et al. (2012), on the other hand, briefly discussed eco-efficiency in the aeroplane industry and resorts as part of tourism.

Table 5. Most global citations

Author(s)	Global citations	Citations per year	Local to global citations ratio (%)	Article title	Source/Journal	Publisher
D'Amato et al. (2017)	600	75.00	0.50	Green, circular, bio economy: A comparative analysis of sustainability avenues	*Journal of Cleaner Production*	Elsevier
Gössling et al. (2005)	**422**	**21.10**	**10.43**	**The eco-efficiency of tourism**	***Ecological Economics***	**Elsevier**
Scheepens et al. (2016)	254	28.22	0.79	Two life cycle assessment (LCA) based methods to analyse and design complex (regional) circular economy systems: Case: Making water tourism more sustainable	*Journal of Cleaner Production*	Elsevier
Becken and Patterson (2006)	**246**	**12.95**	**4.47**	**Measuring national carbon dioxide emissions from tourism as a key step towards achieving sustainable tourism**	***Journal of Sustainable Tourism***	**Taylor & Francis**
Perch-Nielsen et al. (2010)	**161**	**10.73**	**6.83**	**The greenhouse gas intensity of the tourism sector: The case of Switzerland**	***Environmental Science and Policy***	**Elsevier**
Peeters and Schouten (2006)	**145**	**7.63**	**4.83**	**Reducing the ecological footprint of inbound tourism and transport to Amsterdam**	***Journal of Sustainable Tourism***	**Taylor & Francis**
Liu et al. (2017)	**130**	**16.25**	**16.15**	**Tourism eco-efficiency of Chinese coastal cities – analysis based on the DEA-Tobit model**	***Ocean and Coastal Management***	**Elsevier**
Kelly et al. (2007)	**129**	**7.17**	**10.08**	**Stated preferences of tourists for eco-efficient destination planning options**	***Tourism Management***	**Elsevier**
Lynes and Dredge (2006)	117	6.16	0.00	Going green: Motivations for environmental commitment in the airline industry: A case study of Scandinavian Airlines	*Journal of Sustainable Tourism*	Taylor & Francis
Peng et al. (2017)	**112**	**14.00**	**25.00**	**Eco-efficiency and its determinants at a tourism destination: A case study of Huangshan National Park, China**	***Tourism Management***	**Elsevier**

Table 5 (cont.)

Author(s)	Global citations	Citations per year	Local to global citations ratio (%)	Article title	Source/Journal	Publisher
Sun (2016)	107	11.89	4.67	Decomposition of tourism greenhouse gas emissions: Revealing the dynamics between tourism economic growth, technological efficiency, and carbon emissions	*Tourism Management*	Elsevier
García-Melón et al. (2012)	91	7.00	0.00	A combined ANP-Delphi approach to evaluate sustainable tourism	*Environmental Impact Assessment Review*	Elsevier
Cadarso et al. (2016)	89	9.89	5.62	Calculating tourism's carbon footprint: Measuring the impact of investments	*Journal of Cleaner Production*	Elsevier
Becken (2008)	80	4.71	3.75	Developing indicators for managing tourism in the face of peak oil	*Tourism Management*	Elsevier
Tyrväinen et al. (2014)	79	7.18	1.27	Towards sustainable growth in nature-based tourism destinations: Clients' views of land use options in Finnish Lapland	*Landscape and Urban Planning*	Elsevier

Note: Highlighted in bold are seven articles with both high global and local citations.
Source: authors.

Table 6. Most local citations

Author(s)	Local citations	Local to global citations ratio (%)	Article title	Source/Journal	Publisher
Gössling et al. (2005)	**44**	**10.43**	**The eco-efficiency of tourism**	***Ecological Economics***	**Elsevier**
Peng et al. (2017)	**28**	**25.00**	**Eco-efficiency and its determinants at a tourism destination: A case study of Huangshan National Park, China**	***Tourism Management***	**Elsevier**
Liu et al. (2017)	**21**	**16.15**	**Tourism eco-efficiency of Chinese coastal cities – analysis based on the DEA-Tobit model**	***Ocean and Coastal Management***	**Elsevier**
Zha et al. (2020)	18	39.13	Eco-efficiency, eco-productivity, and tourism growth in China: a non-convex metafrontier DEA-based decomposition model	*Journal of Sustainable Tourism*	Taylor & Francis
Qiu et al. (2017)	17	34,69	Tourism eco-efficiency measurement, characteristics, and its influence factors in China	*Sustainability*	MDPI
Kelly et al. (2007)	**13**	**10.08**	**Stated preferences of tourists for eco-efficient destination planning options**	***Tourism Management***	**Elsevier**
Becken and Patterson (2006)	**11**	**4.47**	**Measuring national carbon dioxide emissions from tourism as a key step towards achieving sustainable tourism**	***Journal of Sustainable Tourism***	**Taylor & Francis**
Perch-Nielsen et al. (2010)	**11**	**6.83**	**The greenhouse gas intensity of the tourism sector: The case of Switzerland**	***Environmental Science and Policy***	**Elsevier**

Kytzia et al. (2011)	10	13.89	How can tourism use land more efficiently? A model-based approach to land-use efficiency for tourist destinations	*Tourism Management*	Elsevier
Díaz-Villavicencio et al. (2017)	10	18.52	Influencing factors of eco-efficient urban waste management: Evidence from Spanish municipalities	*Journal of Cleaner Production*	Elsevier
Romano and Molinos-Senante (2020)	9	16.98	Factors affecting eco-efficiency of municipal waste services in Tuscan municipalities: An empirical investigation of different management models	*Waste Management*	Elsevier
Kelly and Williams (2007)	7	31.82	Tourism destination water management strategies: An eco-efficiency modelling approach	*Leisure/Loisir*	Taylor & Francis
Peeters and Schouten (2006)	**7**	**4.83**	**Reducing the ecological footprint of inbound tourism and transport to Amsterdam**	***Journal of Sustainable Tourism***	**Taylor & Francis**
Reilly et al. (2010)	7	16.28	Moving towards more eco-efficient tourist transportation to a resort destination: The case of Whistler, British Columbia	*Research in Transportation Economics*	Elsevier
Sun and Pratt (2014)	5	14.29	The economic, carbon emission, and water impacts of Chinese visitors to Taiwan: Eco-efficiency and impact evaluation	*Journal of Travel Research*	SAGE

Note: Highlighted in bold are seven articles with both high global and local citations.
Source: authors.

Further, seven articles are included in both tables which are significant within the topic of tourism eco-efficiency and for the broader scientific community. The articles consist of four significant publications that were released at the start of this topic's development: Gössling et al. (2005), Becken and Patterson (2006), Peeters and Schouten (2006) and Kelly et al. (2007), along with three additional articles by Perch-Nielsen et al. (2010), Liu et al. (2017) and Peng et al. (2017). Perch-Nielsen et al. (2010) published a significant article that examined both top-down and bottom-up approaches to GHG impacts on the tourism industry in Switzerland. On the other hand, Liu et al. (2017) and Peng et al. (2017) initiated a surge in articles on tourism eco-efficiency from China, some of which utilized the data envelopment analysis (DEA) method, the most implemented in this field. The seven articles are highlighted in bold font in both tables.

3.4. COUNTRY-BASED ANALYSIS

In the country-based analysis, we compiled each of the 10 countries with the highest productivity levels and impacts. Both are shown in Table 7 and Table 8 where China is the leading country in both categories, having published 59 articles with a total of 999 citations. However, there is a huge discrepancy between single country publications (SCP) and multiple country publications (MCP), indicating the rare involvement of authors from other countries. Spain and Chile were the second and third most prolific producers of papers, indicating a strong level of collaboration between them.

Table 7. Most productive countries

No.	Country	Single country publications (SCP)	Multiple country publications (MCP)	Articles	Total
1.	China	55	4	59	220
2.	Spain	3	3	6	30
3.	Chile	1	4	5	11
4.	Canada	3	1	4	10
5.	Switzerland	3	0	3	7
6.	Australia	1	1	2	3
7.	Finland	1	1	2	11
8.	Italy	1	1	2	4
9.	Netherlands	2	0	2	7
10.	New Zealand	2	0	2	4

Source: authors.

Table 8. Most impactful countries

No.	Country	Total citations (TC)	Average citations (AC)	Total citations in Vosviewer (TCV)
1.	China	999	16.9	892
2.	Finland	679	339.5	689
3.	Sweden	422	422.0	428
4.	Netherlands	399	199.5	829
5.	New Zealand	326	163.0	374
6.	Canada	311	77.8	311
7.	Switzerland	243	81.0	243
8.	Spain	215	35.8	245
9.	Australia	91	45.5	208
10.	Chile	81	16.2	142

Source: authors.

We also analysed the same data using Vosviewer as a comparison. From Vosviewer data, Germany, the United Kingdom, the USA, Italy and France should be included as the most impactful countries because they have a high number of citations as some of the authors are among the co-authors of Gössling et al. (2005). Four nations, excluding Italy, are classified as 'others' in the analysis of the most productive countries. This classification prevents the identification of the number of articles published by authors from or affiliated with institutions in these countries. Another important highlight is Taiwan which was identified as a contributor nation in Vosviewer but not in Biblioshiny. We suspect that this is because of the potential impact of the high number of articles coming from China in recent years.

We proceeded with the country-based network analysis, as depicted in Figure 4, categorizing the 22 countries into six clusters. The figure also confirms the preceding two paragraphs that China holds a prominent position as illustrated with a substantial node size. The strong connection between Spain and Chile is also highlighted by the thick line representing their relationship. On the other hand, according to the Biblioshiny data we analysed, 27 countries were expected to be identified, while the Vosviewer data revealed 29. Excluded from the network analysis were Kazakhstan, Peru, Portugal, Thailand and the United Arab Emirates. Taiwan and Hong Kong were identified in Vosviewer but not in Biblioshiny.

3.5. KEYWORD-BASED ANALYSIS

The keyword-based analysis covers comparable keywords typically seen in the context of tourism eco-efficiency. The analysis uses a clustering mechanism and a quadrant-based approach using keyword dynamics, particularly keyword plus, to obtain new insights. Keywords plus holds the largest number of keywords on a database, specifically 573. This conceptual structural analysis framework is categorized in two forms: factorial analysis and thematic analysis. Factorial analysis forms a cluster based on two dimensions using the correspondence analysis method, while theme analysis involves quadrant-based mapping, temporal change and a combination of both.

Figure 4. International collaboration networks
Source: authors

3.5.1. FACTORIAL ANALYSIS

We conduct factorial analysis using the correspondence analysis method, which limits dimensions division to two, unlike multiple correspondence analysis, which splits into more than two dimensions. We further limit the number of words described to a maximum of 170 as this quantity is deemed sufficiently representative. Despite using up to 573 keywords, the analysis only included a set of 78 articles out of the total 99. We also divided the parameters into eight clusters whose distribution and division of these clusters are shown in Figure 5.

Cluster 1 in red consists of various keywords that discuss the intersection between the economy and the environment within the tourism sector. Some of the 51 keywords in this cluster are economic impact, environmental pollution, industrial development, sustainability, strategic approach and technological development. This cluster contains 36 publications, four of which are considered noteworthy in the works of Gössling et al. (2005), Becken and Patterson (2006), Perch-Nielsen et al. (2010) and Peng et al. (2017).

Cluster 2, denoted in blue, encompasses 37 keywords associated with conservation and environmental management in specific ecosystems, including conservation, artificial wetlands, parks, national parks, forest parks, river water, forest ecosystems and ecosystems. In addition, this cluster incorporates keywords on methodological frameworks utilized in environmental analysis, such as social network analysis, regression analysis, optimization, network and geographical analyses. Notable contributions within this cluster include works by Sun and Hou (2021),

Wang et al. (2022) and Guo et al. (2022) among the 12 articles.

Cluster 3 (green) mostly highlighted efficiency-related analysis, particularly with various techniques based on the process of measurement or assessment. The widely used DEA and stochastic-based techniques, e.g. stochastic frontier analysis (SFA), are among the techniques listed. There are only three articles in this cluster: Liu et al. (2017), one of the significant articles, and Díaz-Villavicencio et al. (2017) with Sala-Garrido et al. (2022) which are closely related to the following cluster on the topic of waste management in tourism.

As its name implies, cluster 4 (purple) displays 24 terms associated with waste management as an undesirable output in tourism eco-efficiency as well as a function of population dynamics. Additionally, two country keywords – Spain and Chile – with studies that most frequently address this subtopic are included in cluster 4. The six studies in this cluster are Romano and Molinos-Senante (2020), Llanquileo-Melgarejo and Molinos-Senante (2021), Delgado-Antequera et al. (2021), Molinos-Senante et al. (2023a, 2023b) and Sala-Garrido et al. (2023).

The discussion in the next cluster 5 (orange) is more focused on tourist destinations as markets, including their relevance to tourist management and behaviour. Several of the 18 keywords in this cluster are typically names of places or tourist destinations, such as Asia or Europe, and a few nations like Taiwan and Switzerland. This cluster contains eleven articles including Peeters and Schouten (2006), Kelly et al. (2007), Lynes and Dredge (2006), and Sun (2016).

Even though there are just 14 keywords dispersed throughout cluster 6 (brown), it has a larger coverage
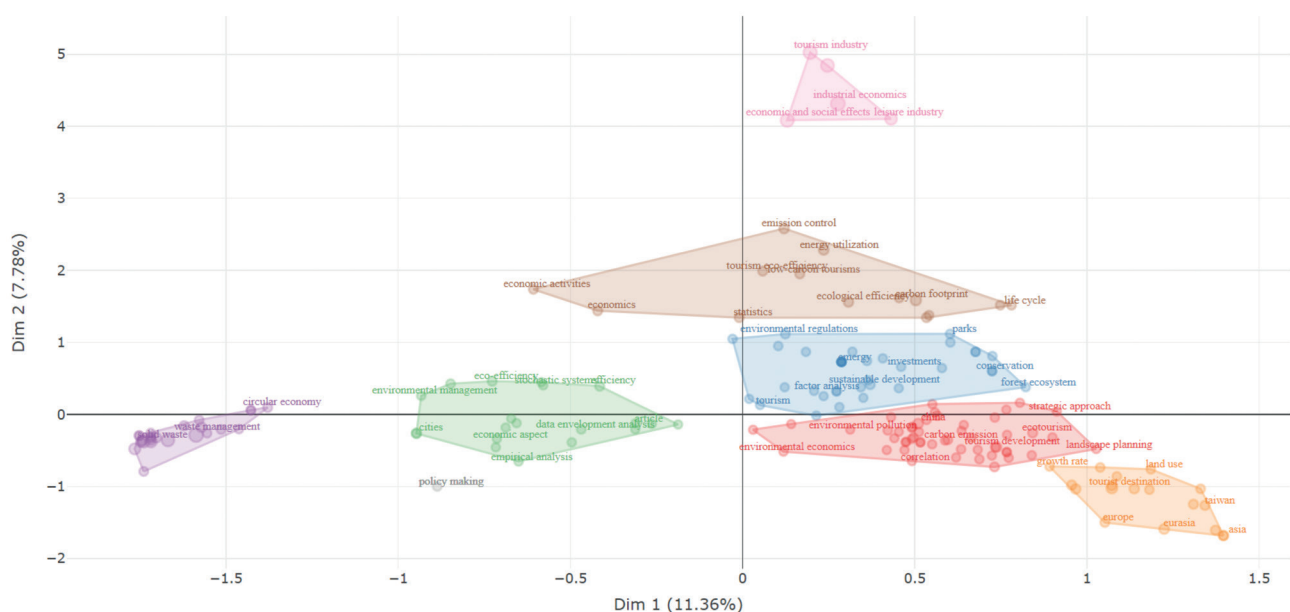

Figure 5. Factorial analysis
Source: authors

area than the others. This cluster frequently includes themes like energy utilization, low-carbon tourism, ecological efficiency and others that deal with the relationship between the economy and the environment. This cluster consists of eight publications, including D'Amato et al. (2017), Scheepens et al. (2016) and García-Melón et al. (2012) which have received high citation numbers.

For the last two clusters, cluster 7 (pink) includes five keywords that tend to discuss the industrial side, while cluster 8, which is grey in this instance, is mostly concerned with creating supportive tourism-related policies. Each of the clusters was based on one article. The primary source for cluster 7 is the paper on the bamboo industry written by Wang et al. (2021) as supporting commodities for the economic benefits of tourism and environmental sustainability. Llanquileo-Melgarejo et al. (2021) in cluster 8 discuss policy making related context in waste management to support tourism management. Table 9 provides a detailed and concise explanation of the clusters, as well as the breakdown of keywords, numbers of keywords and articles in each cluster.

3.5.2. THEMATIC ANALYSIS

The thematic analysis combines two elements from the previous analysis which concentrated on categorizing themes into thematic quadrants, comprising four categories: motor, basic, niche and emerging or declining. Cluster formation is determined by centrality measures consisting of betweenness, closeness and page rank, rather than being dependent on occurrence frequency. A high proximity centrality value suggests that the keyword serves as a crucial link between clusters and has a significant effect within the cluster. Page rank centrality is used to analyse the relationship between citations and important keyword patterns.

Figure 6 shows that keywords are categorized into 13 different clusters, with a total of 157 extracted from 55 out of the 99 articles reviewed. There are five clusters in the motor themes quadrant which have the largest centrality measures. These are cluster 5: China (64 keywords), cluster 9: efficiency (39), cluster 7: sustainable tourism (8), cluster 3: agglomeration (9), and cluster 1: cluster analysis (11). Keywords include tourism, sustainable development, efficiency, China, data

Table 9. Factorial analysis clusterization

|	Cluster	Selection of keywords	No. of keywords	No. of articles
1	Environmental and economic implications	tourism development, human environmental protection, environmental policy, pollution, sustainable development goal, economic impact, environmental pollution, industrial development, sustainability, strategic approach, technological development, environmental impact, etc.	51	36
2	Environmental management and conservation	forestry, conservation, constructed wetland, parks, national park, forest park, river water, forest ecosystem, ecosystems, wetlands	37	12
3	Efficiency analysis and productivity	efficiency, data envelopment analysis, eco-efficiency, cities, productivity, decision making, efficiency measurement, environmental factor, bootstrapping, socio-economic factor, stochastic model, stochastic systems, valuation	20	3
4	Waste management, population, and circular economy	waste management, municipal solid waste, solid waste, recycling, municipal solid waste management, circular economy, Chile, Spain, undesirable output, eco-efficiency assessments, population densities, population statistics, population density	24	6
5	Tourism market and destination	tourist destination, tourism management, tourism market, tourist behaviour, Eurasia, Taiwan, Asia, Australia, Europe, Switzerland, growth rate, greenhouse gas, input-output analysis, land use	18	11
6	Ecological and economic interactions	carbon footprint, ecological efficiency, ecology, economics, statistics, energy utilization, emission control, life cycle, low-carbon tourisms, tourism eco-efficiency	14	8
7	Tourism and leisure industry	economic and social effects, industrial economics, agricultural robots, leisure industry, tourism industry	5	1
8	Policy making and regulation	policy making	1	1

Source: authors.
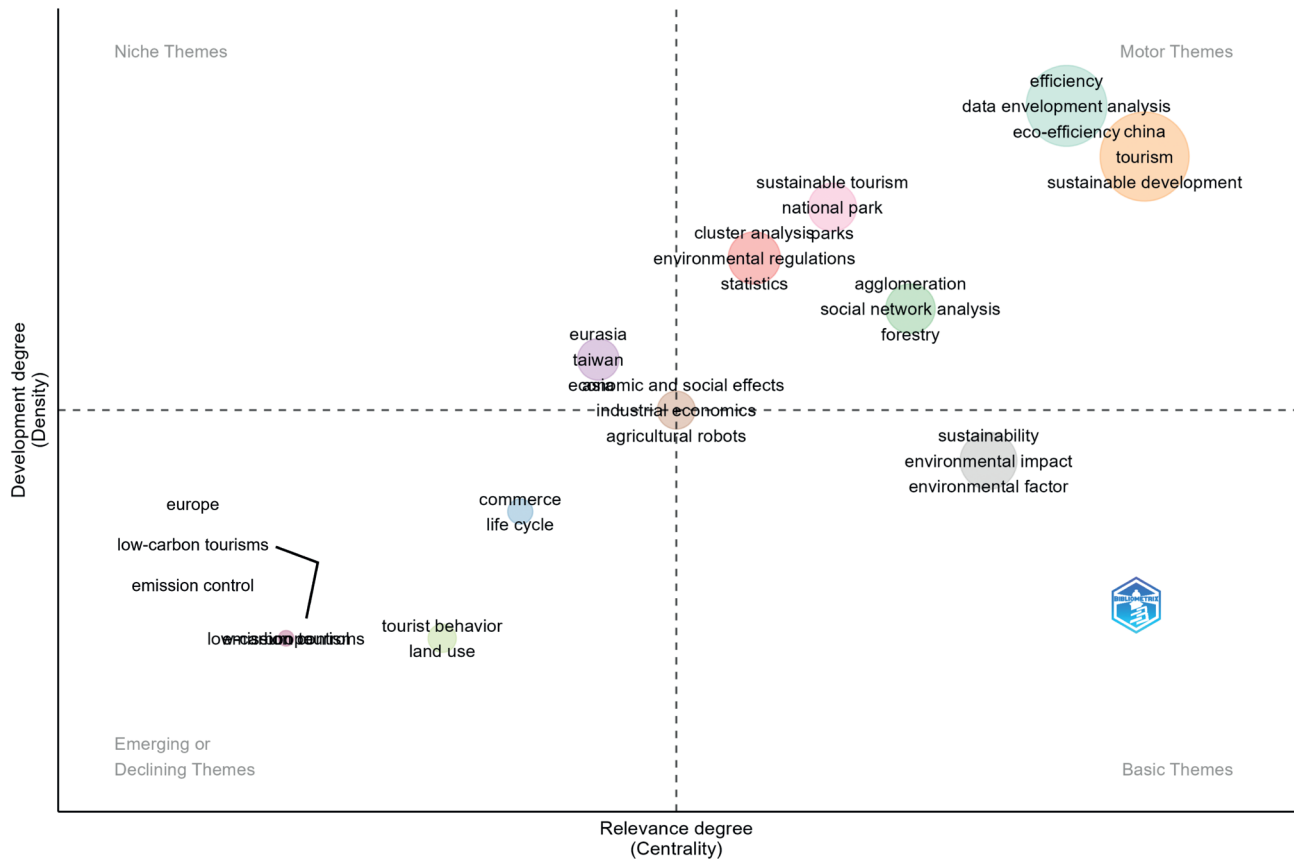
Figure 6. Thematic clusters
Source: authors

envelope analysis, carbon footprint, spatiotemporal analysis, waste management, decision-making, etc. There are 131 keywords with 680 total occurrences distributed among the five clusters in the motor theme quadrant. These keywords have appeared as the dominant discussion topics in tourism eco-efficiency.

In the basic theme quadrant, there is only one cluster, identified as cluster 8: sustainability, consisting of 10 keywords. Cluster 4, Eurasia, consists of five keywords associated with tourism destinations categorized in the niche theme quadrant. Cluster 6, focused on economic and social effects, is the only one that is included in the four clusters, indicating moderate connectivity within the network. Lastly, there are five minor clusters containing seven keywords in the emerging (or declining) theme quadrant. Figure 6 displays two distinct clusters: cluster 2 focuses on commerce and cluster 13 focuses on tourist behaviour. Additionally, three overlapping clusters are identified as cluster 10: Europe; cluster 11: low-carbon tourism and cluster 12: emission control.

3.5.3. Thematic evolution

We further conducted a thematic analysis by splitting the data into four different periods, allowing us to pinpoint shifts in the discourse surrounding the tourism eco-efficiency subject across time. To find themes that are infrequently mentioned throughout each period, we concentrate on niche and emerging or declining themes. For instance, as Figure 7 illustrates, during the first phase (2005–2008) the integration of the concept and framework of tourism eco-efficiency was still developing, therefore the focus remained on tourism development. In the next period (2010–2014) as shown in Figure 8, the tourist destination cluster, which also contains tourism development keywords, was contained in both quadrants, signifying the lack of discussion on this topic after 2009 when there were no articles published on the tourism eco-efficiency theme.

During the next period (2016–2019), keywords that were formerly associated with emerging themes have now been incorporated into motor themes. As shown in Figure 9, in the tourism development cluster, keywords such as China and DEA were significant, consistent with research carried out in China at different levels, including national, subnational and local or municipal levels (Han, 2019; Liu et al., 2017; Peng et al., 2017; Sun & Hou, 2021; Wu et al., 2019). It is also connected to DEA as the primary method for assessing eco-efficiency in tourism, such as Peng et al. (2017) who employed the slacks-based measure DEA (SBM-DEA) to evaluate the eco-efficiency of the tourism industry and Liu et al. (2017) with the DEA-Tobit model to assess the efficiency of tourism destinations.
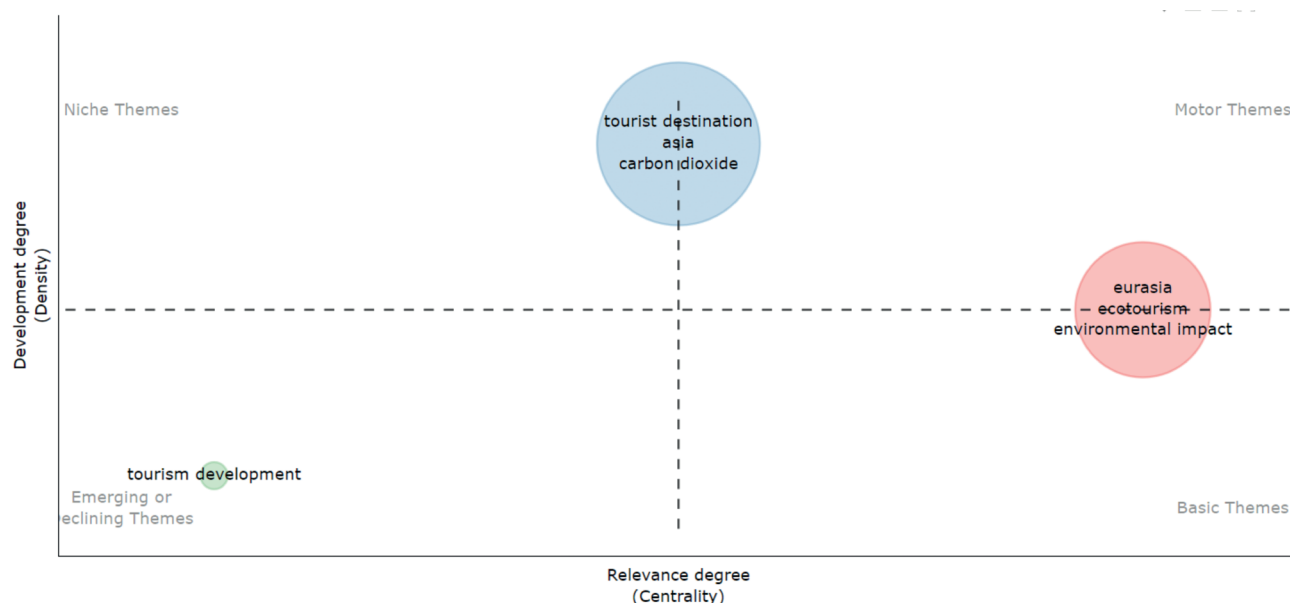
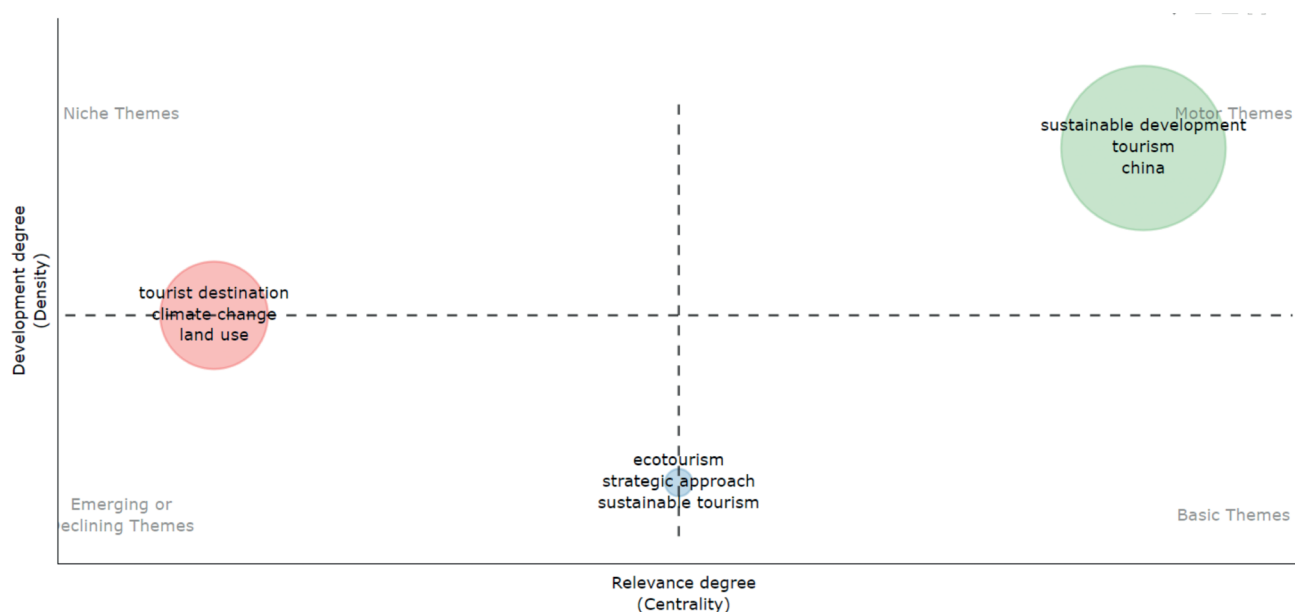Figure 7. Thematic evolution 1 (2005–2008)
Source: authors

Figure 8. Thematic evolution 2 (2010–2014)
Source: authors

The cluster life cycle, exhibited as emerging themes, is supported by rising citation rates in studies by Scheepens et al. (2016) and Cadarso et al. (2016).

The recent period demonstrates how three major clusters that contain multiple keywords – China, DEA, efficiency, tourism development, ecotourism, investment, spatiotemporal analysis, etc. – have solidified as motor themes. One of the causes is the rise in articles written by Chinese authors using the DEA method, such as Haibo et al. (2020), Sun and Hou (2021), Li et al. (2021) and Lu et al. (2021). However, clusters like low-carbon tourism, emission control, cluster analysis and optimization belong to niche and emerging or declining themes. It is

evident that while some clusters and keywords in the thematic analysis are congruent with niche and emerging or declining themes, others cross over into motor themes, particularly in the recent period of thematic evolution. We highlight that low-carbon tourism and emission control tend to represent declining themes. In the meantime, other clusters that we evaluate will develop into niche or emerging themes; some of them have even begun to become motor themes, and will include keywords like optimization, factor analysis, spatial analysis/variation, cluster analysis, environmental regulations, spillover effect, emission control and low-carbon tourism. These are all shown in Figure 10.
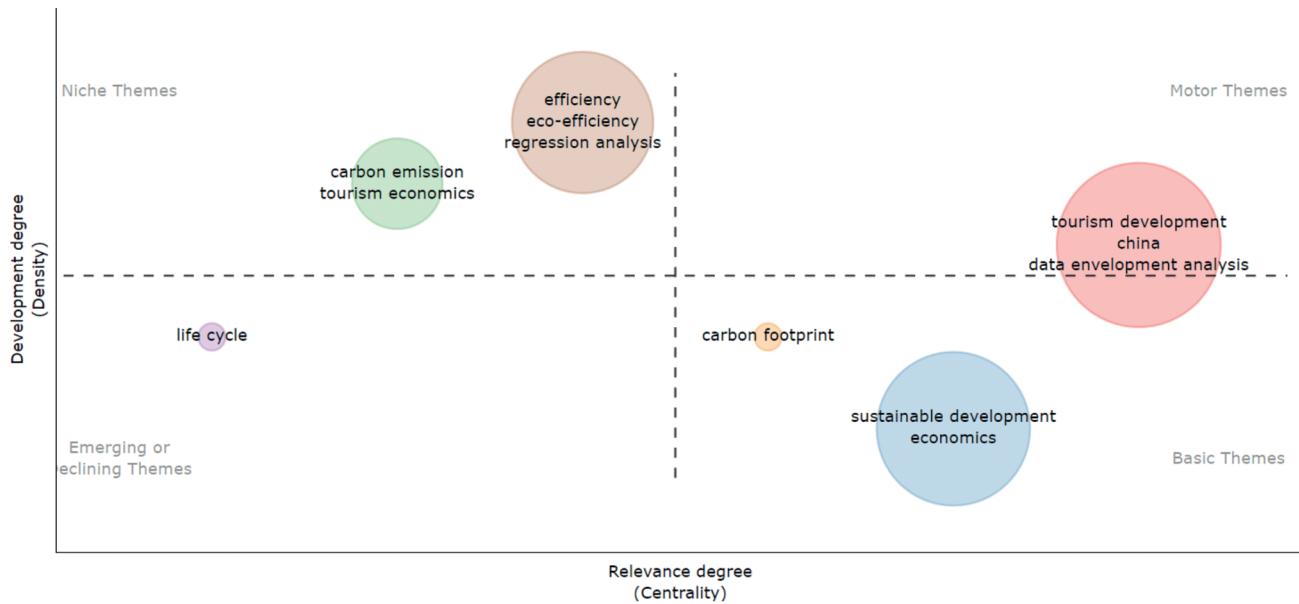
Figure 9. Thematic evolution 3 (2016–2019)
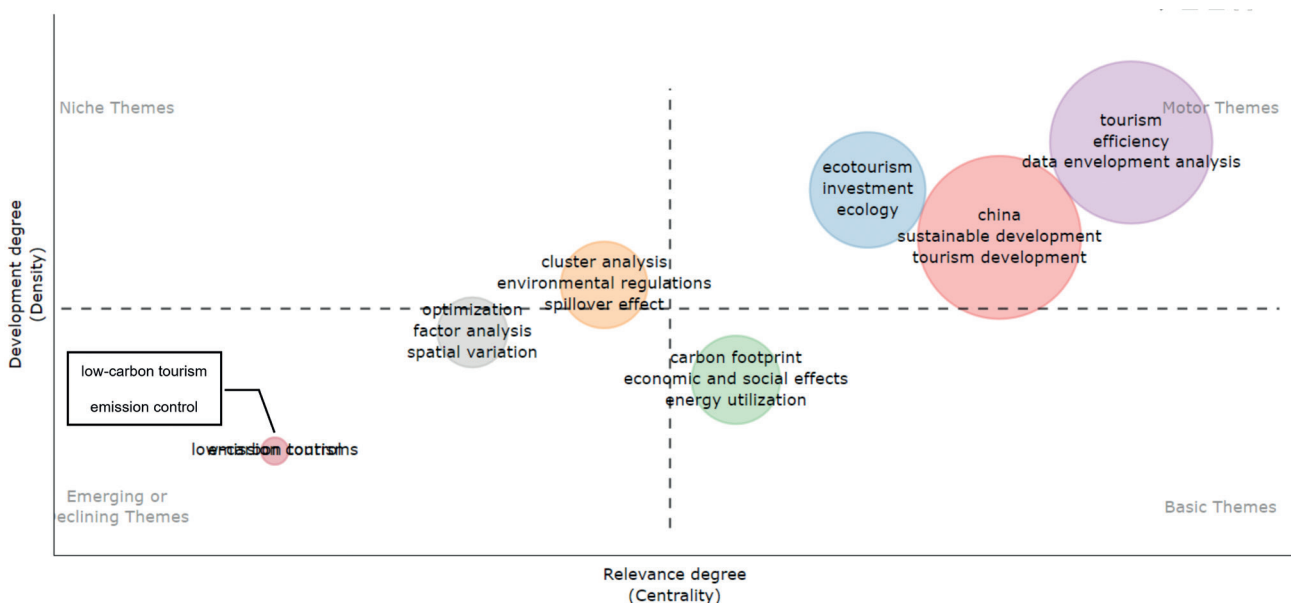Source: authors

Figure 10. Thematic evolution 4 (2020–2023)
Source: authors

4. Conclusions

This study has examined the evolution of tourism eco-efficiency as a research issue over almost two decades and explores future opportunities for the research area. We conducted five analyses, beginning with a general, followed by source-based, author-based, country-based, and an in-depth keyword-based. The latter serves as a critical variable for exploring future thematic research potential, employing factorial and thematic analyses, and their evolutionary dynamics. From the general analysis, we observed that out of the 99 articles reviewed since 2005, the majority were published after 2019,

indicating a significant rise in academic interest in the field of tourism eco-efficiency over the previous five years. Despite this growth, there remains many opportunities for future research collaboration, as the number of articles involving international co-authorship is still relatively low.

In source-based analysis underlining the significance of six key journals: *Ecological Economics*, *Journal of Cleaner Production*, *Journal of Sustainable Tourism*, *Tourism Management*, *Waste Management* and *Current Issues in Tourism*, emerged as both relevant and impactful as discourse platforms for the tourism eco-efficiency topic. Further, in the author-based analysis, contrast

between local and global citations reveals a mix of overlap. This study also identified 15 articles with the highest global citations, of which four address global issues but receive minimal local recognition or citations, while also highlighting seven pivotal articles in the field of tourism eco-efficiency, including foundational works and recent contributions that utilize data envelopment analysis (DEA) as main method in tourism eco-efficiency research, particularly from China. The increase in publications using DEA also serves as one reason for China's status as most productive and impactful country, as evidenced by its citation number in the country-based analysis. This is further supported in network analysis, wherein 22 countries having divided into six clusters, China had become the country with the highest number of connections to research institutions in other countries. The expansion in international research collaboration and the tendency to employ diverse, interdisciplinary methodologies will be critical focal points moving forward.

The keyword-based analysis of tourism eco-efficiency identified 573 keywords through a clustering mechanism and a quadrant-based approach, which then analysed through factorial and thematic analyses. In factorial analysis, 78 representative articles were divided across eight clusters, while thematic analysis categorized thirteen clusters of keywords from 55 articles into motor, basic, niche and emerging or declining themes based on centrality measures. The quest to identify potential future research topics is informed by an examination of the evolving dynamics within the quadrants representing niche and emerging or declining themes. To this end, we undertook a thematic analysis grounded in temporal segmentation, which unveiled a range of promising keywords for exploration. These include concepts such as optimization, factor analysis, spatial analysis/ variation, cluster analysis, environmental regulations, spillover effects, emission control and low-carbon tourism, all of which warrant further exploration.

At last, while this study offers insights into the field of tourism eco-efficiency, it comes with certain limitations. First, the bibliometric analysis, albeit extensive, relies on the Scopus database, potentially excluding relevant sources from other databases such as Web of Science, JSTOR, etc. The bibliometric techniques employed may introduce biases, especially if certain journals or regions are over-represented, as highlighted by China's publication dominance, and technical errors that boost such biases, especially author identification. This article is also limited by not involving non-English publications, which potentially skews the representation. The study's reliance on quantitative metrics may not fully capture the nuanced or qualitative aspects of the articles.

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