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Worldwide Research on Geoparks through Bibliometric Analysis

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Abstract: Since the Digne Convention in 1991, the literature related to Geoparks has gained a growing interest on the academy's part, especially in achieving the preservation of geological interest sites through sustainable tourism. This article aims to provide an analysis of the academic research on Geoparks, based on publications in the Scopus database in the period 2002–2020. Bibliometric analysis methods and bibliographic display maps were examined using VOSviewer software. The bibliometric analysis process comprises three phases: (i) Search Criteria and Source Identification, (ii) software and data extraction, and (iii) data analysis and interpretation. The results show geoparks in full growth as a scientific discipline, thanks to the contribution of various authors, institutions, journals, and related topics that confirm the importance of this field of study. Additionally, bibliometric maps lead to an understanding of the intellectual structure of the subject, in which keyword co-occurrence analysis shows six main themes, ranging from 'UNESCO Global Geoparks' to 'Geo-tourism-Sustainable Tourism'. this, combined with maps of co-citation, broadly exhibits this structure and development, showing areas of current interest and potential development, thus offering the latest knowledge on Geopark research worldwide. There is a growing concentration of research on geomorphological heritage and geo-tourism, focusing on methodologies to evaluate the specialities of this type of heritage and define the concept of geo-tourism; there is a great interest especially in the evaluation and identification of geo-site/geo-morphosites which try to eliminate subjectivity in methods and focus on sustainable development of the localities.

Keywords: geopark; geo-tourism; bibliometric analysis; co-occurrence; co-citation; VOSviewer

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1. Introduction

Geodiversity is the natural variety of geological, geomorphological, and soil elements involved in the structure of, and physical processes on, the Earth's surface [1]. In turn, it is a word that denotes abiotic events on our planet, being the fundamental aspect of geo-conservation and the means of promoting Geoparks in society [2]. Geological heritage, or geo-heritage, is a part of geodiversity considered for preservation [2], given that the weighting by different types of values (economic, scientific, educational, cultural, intrinsic, or aesthetic) is specific, and these elements of geodiversity can be used sustainably in the scientific, educational, and geo-tourism fields [3].

Geo-tourism is a sustainable tourism form within the natural and cultural environment of a territory that brings economic development to the community [3,4], focusing on the geological and landscape component as the foundation of tourism [5], enabling the promotion of geo-sites and geo-conservation through the appreciation and teaching of Earth sciences [6]. Geo-sites make up a part of the Earth's surface, which allows us to understand the evolution of Earth, being elements with scientific, scenic, economic, and cultural value [7] which are promoted under the UNESCO Global Geoparks program, enabling protection due to their regional importance [8].

Geoparks comprise a region with relevant geo-sites, favouring economic and local development through sustainable tourism, achieving preservation and educational objectives [9], e.g., the Hong Kong Geopark in China [10]. In a geopark located in the middle of a densely populated urban area, where thanks to an efficient management system of conservation, promotion, and collaboration (with other Geoparks and the local community), optimal tourist infrastructure, and ease of scientific interpretation and teaching [11], it is possible to combine, in areas with these characteristics, the conservation of geo-heritage with sustainable development.

The Geopark concept was first developed in the late 1980s in Europe, where a geopark was exposed, with its distinctive geo-heritage, to a territorial sustainable development strategy [9]. A group of scientists with experience in geo-conservation made the first international initiative in the Netherlands in 1988, establishing the European Working Group (which in 1993 became ProGEO—The European Association for the Conservation of the Geological Heritage) [12]. In 1989, the first Geopark was established in Germany, the Gerolstein/Vulkaneifel District Geopark [13,14].

In the 1990s, the geoscientific community proposed two new global initiatives: the Global Indicative List of Geological Sites (GILGES), later renamed the Global Geo-sites Project [15,16], and in 1991 the UNESCO Geoparks Program, which was proposed for the first time [17]. Later, in June 2000, the European Geoparks Network (EGN) was created, formed by four Geoparks, including the first German geopark in conjunction with three others, Reserve Geologique de Haute-Provence (France), Maestrazgo Cultural Park (Spain), and the Natural History Museum of Lesvos Petrified Forest (Island of Lesvos, Greece) [14]. However, in 2001, the UNESCO Geoparks Program's first attempt ended unsuccessfully at the 161st Session of the Executive Board of UNESCO [9], where the idea of a geological sites and parks program was renounced [18].

On 20 April 2001, UNESCO gave its support to the network, by signing in Almería the cooperation agreement between EGN and UNESCO's Division of Earth Sciences. In February 2004, the Global Geoparks Network (GGN) was created through the Madonie Declaration [19], and the EGN was recognized as the body that regulates entry to the GGN [9]. Finally, a new label, 'UNESCO Global Geoparks' (UGG), was established on November 17, 2015, by the Member States of UNESCO, within a new program called the International Geoscience and Geoparks Program (IGGP) [20].

Currently, around the world there are 161 areas that have been declared as UNESCO Global Geoparks distributed in 44 countries [21], mainly found in Europe and China, where the East Asian country leads the UNESCO Global Geoparks list with 41 officially recognized areas, the Xiangi geopark (a place that combines Paleolithic and Neolithic period cultural heritage sites with features that evidence area tectonics such as the Yangtze Platform) and Zhangye Geoparks (the site that houses the 'Nine-Springs' ophiolite) being the two new iconic Geoparks designated in July 2020.

In simple terms, Geoparks are areas with geological characteristics of international relevance, whose purpose is to seek sustainable development from the community of influence and the excellent use of natural resources, including education in geosciences, biodiversity, geological mining heritage, tourism, conservation, technical development, and research at all levels of education [22,23]. On its website, UNESCO presents the 10 priority areas of UNESCO's Global Geopark programme (see Figure 1) [24] and how the geopark initiative promotes respect, awareness, renewable energy practices, and better standards of 'green tourism', research, dissemination, cultural rescue, inclusion, local development, participation, and protection.

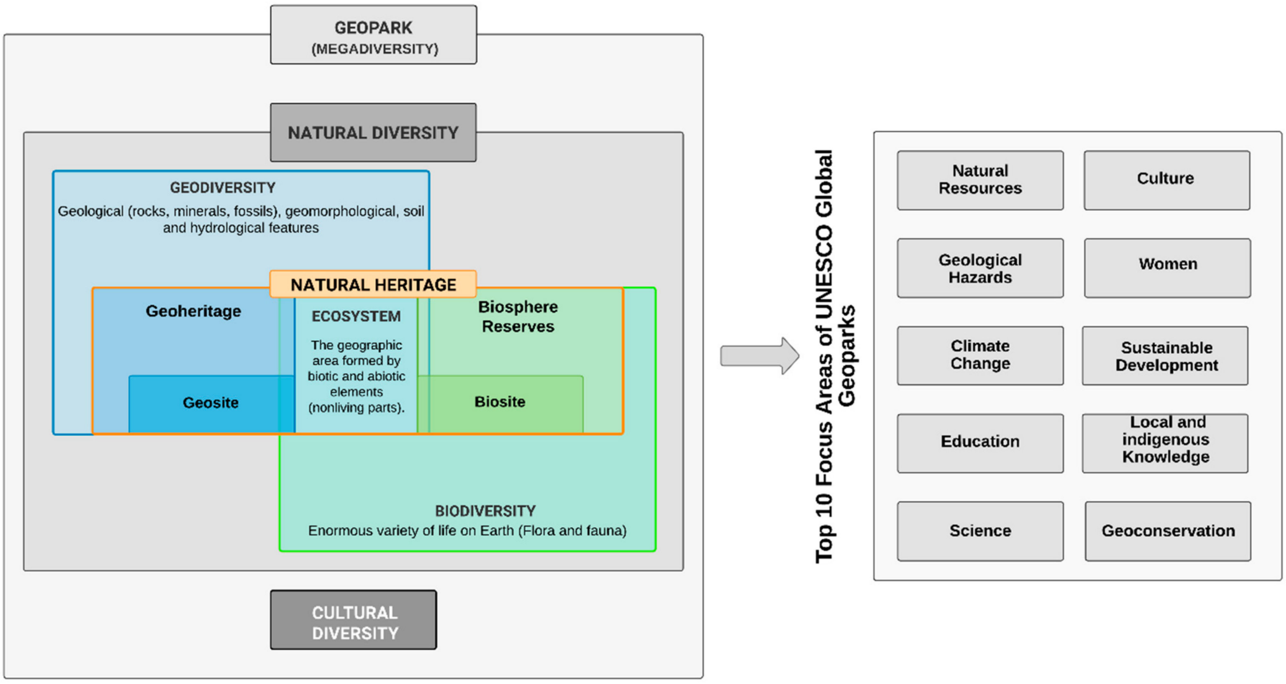


Figure 1. Conceptual scheme on megadiversity, biodiversity and geodiversity.

The concept of Geoparks is based on geological relevance as an aspect of geodiversity, integrating aspects of biodiversity and people in their cultural and territorial environment [25]. Megadiversity refers to regions with a high biodiversity or diversity of ecosystems and species, but it is undoubtedly a conjunction of two components (geodiversity and biodiversity). In Figure 1, a conceptual scheme of Geoparks, concerning biodiversity and geodiversity, is shown.

The geopark concept has gained worldwide recognition in less than 20 years [9], and its growth is reflected in the number of sites officially designated as UNESCO Global Geoparks [21]. Although Geoparks are concentrated in Europe and Asia, in recent years the initiative has been spreading in Latin America, taking advantage of its ethnic, cultural, geographical, climatic, and above all geological diversity [26]. Latin America already has eight sites of recognized geological heritage: Araripe (Brazil, 2006) [27], Grutas del Palacio (Uruguay, 2013), Comarca Minera and Mixteca Alta (México, 2017) [28], Colca y Volcanes de Andagua (Perú, 2019) [29], Kütralkura (Chile, 2019) [30], Imbabura (Ecuador, 2019), and Rio Coco (Nicaragua, 2020). The emerging potential of initiatives in Latin America has led to the development of new geopark projects in the region (e.g., [31–39]).

Since a geopark contains sites whose geological characteristics are of international relevance and offers a trip that allows one to understand the evolution of geological time [40,41], it is a subject that has aroused interest at a global level, and has generated a large number of scientific publications in various branches of knowledge. Some studies have expanded knowledge of Geoparks by focusing on their conception, operation, and benefits [42], the needs of public education programs and community awareness initiatives [43,44], or their history and progress [45]. Some studies address Geoparks in general, but do not analyze their evolution, trends, and intellectual structure.

One of the most commonly used research tools to study and analyze scientific activity are bibliometric methods [46–48]. Bibliometric analysis can quantitatively measure and evaluate the impact of research on a topic of interest, identifying past characteristics and critical points in the present and suggesting research trends in the future [49,50].

In this context, the following question arises: is it feasible that a bibliometric analysis of data and information allows us to know how Geoparks arose and where these investigations are projected, in a context of sustainable development? Geopark studies associated with bibliometric research are presented as an exciting contribution to the scientific community that can guide evolution and trends and suggest innovative creative possibilities. These reflections allow us to propose that a bibliometric study of the subject will help discern strategies/trends/opportunities related to geopark projects and their sustainability.

The aim of this study is bibliometric analysis evaluating scientific research related to Geoparks through the use of the Scopus database and VOSviewer software, applying the VOS mapping and clustering technique [51], to determine scientific structure (major countries, documents, institutions, keywords, authors, and journals), development, patterns, and research trends.

2. Materials and Methods

The literature review plays a fundamental role in managing the knowledge of a subject within a research area to map and evaluate scientific production [52]. These reviews require a formal and rigorous methodological procedure, capable of reproduction, an exhaustive analysis, and transparent contextual relationships, i.e. a systematic review of the literature [53,54]. This rigour is also present in bibliometric analyses [55,56].

Bibliometric analysis is a quantitative application that allows the study of scientific production—its characteristics, evolution, and monitoring [57]. Two procedures are employed: (a) analysis of scientific production performance, leading to an evaluation of the impact of the field of study and its scientific actors (countries, universities, and authors) [58,59] and (b) bibliometric mapping in combination with a clustering technique, revealing, by analyzing its topics, disciplines and research fields, the cognitive structure and behaviour of the scientific field [60,61]. Bibliometric studies are available in various fields such as management [62,63], education [64,65], and geoscience [66–69].

This study employs a three-phase methodology (see Figure 2): (i) search criteria and source identification, (ii) software and data extraction, and (iii) data analysis and interpretation (bibliometric and mapping analysis).

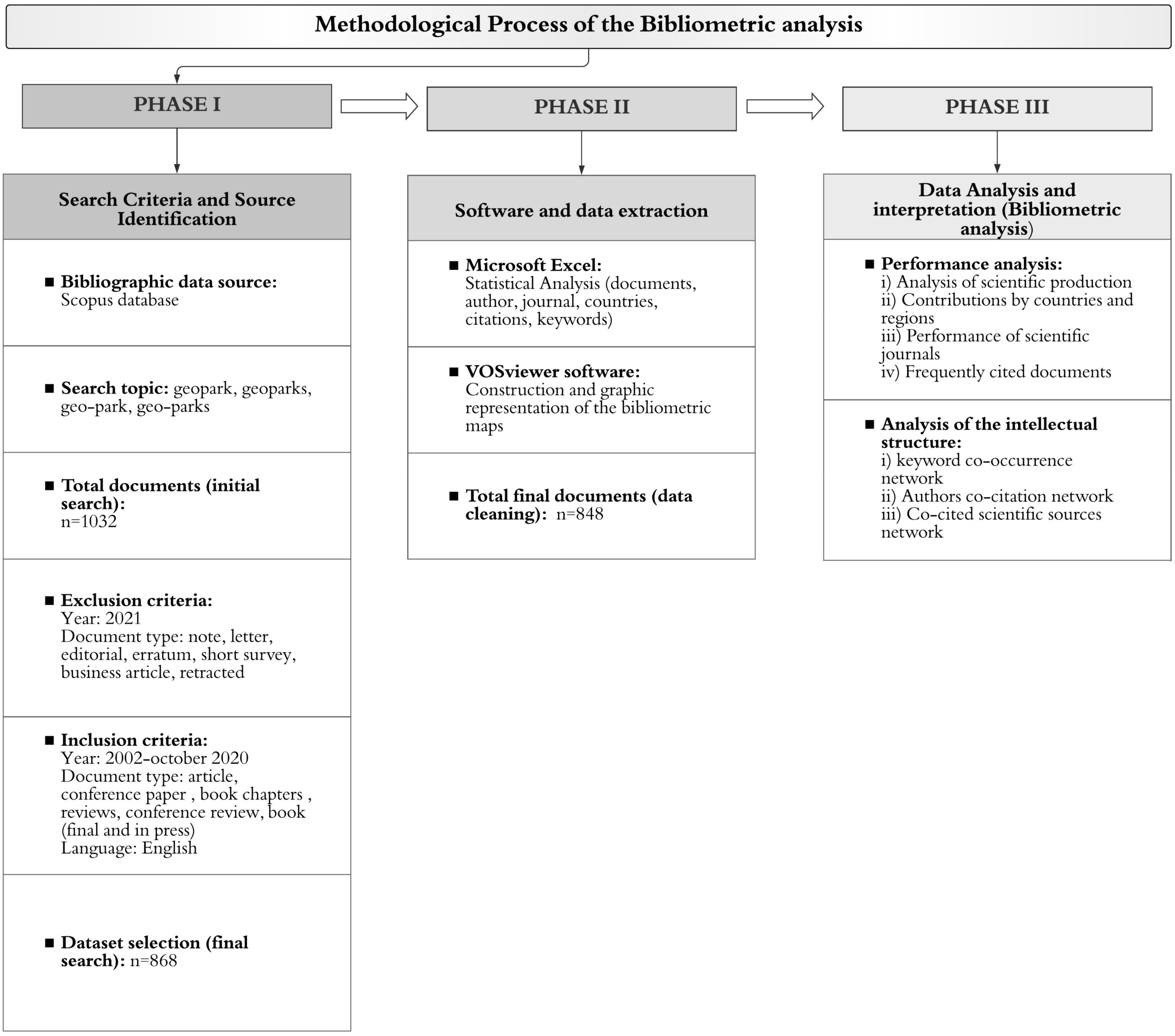


Figure 2. Developed method diagram illustrating the process carried out in the present study.

2.1. Phase 1. Search Criteria and Source Identification

We proceeded to identify the field of study of 'Geoparks', which establishes the objectives: to analyze the results (scientific production, researchers, institutions, or countries) and to recognize the structure and evolution of the discipline [48,60].

For the construction of the field of study database, it is necessary to meet the transparency requirements of the process used by bibliometric studies, which are a set of implicit and explicit selection criteria for the documents obtained from the database. The inclusion criterion of the study was restricted to the Scopus database, which was selected based on its broad coverage of scientific documents that have been reviewed by blind peers, as well as its use as a platform that facilitates bibliographic information export [70,71] and that, for the field of study, presents excellent coverage of geoscience journals [72].

The data collection was carried out on 1 October 2020, using the descriptors geopark, geoparks, geo-park, and geo-parks, contained in title, summary, and keywords, in conjunction with Boolean logical functions, such as AND OR, leading to the following search topic: (TITLE-ABS-KEY (Geopark) OR TITLE-ABS-KEY (Geoparks) OR TITLE-ABS-KEY (geo-park) OR TITLE-ABS-KEY (geo-parks)). This search yielded a collection of 1032 documents.

Consequently, different filters were applied to the database obtained. As inclusion criteria, the use of articles (final and in press), article reviews and conference papers were chosen. Additionally, book chapters and books were considered, which yielded

1017 records. The search was limited to English (868 records), considered the most frequent language in scientific publications [73].

2.2. Phase 2. Software and Data Extraction

The data collection in Scopus was exported in CSV format (comma-separated values) in the Microsoft Excel software Office 365 ProPlus. This is used for the review, debugging, and statistical analysis of database data sets [70]. The downloaded metadata includes Authors, Affiliations, Title, Publication Years, Cited Publications, Abstracts, Author Keywords, Index Keywords, references, and other relevant bibliographic information that needs to be reviewed and refined. For this purpose, records that did not show authorship, duplicate documents, or records with errors were eliminated, leading to a final database of 848 documents.

In the construction and graphic representation of intellectual structures, VOSviewer software, developed by Leiden University, has been used to construct two-dimensional distance-based maps with a capacity greater than 10,000 items [51,60]. The software has been used in various areas: business, management and accounting [74], environmental science [75], cultural and natural heritage [76], medicine [77,78], earth sciences [79–82], and physics [83].

2.3. Phase 3. Data Analysis and Interpretation (Bibliometric Analysis)

In the information analysis and interpretation, the combination of the two bibliometric analysis approaches, (i) performance analysis and (ii) analysis of intellectual structure, known as Science Mapping, was used [60,84].

The first focuses on the analysis of scientific production using bibliometric indicators: published articles, contributions by countries and regions, frequently cited documents, and the performance of scientific journals [85,86]. Additionally, such performance indicators as H-Index and Cite Score were used [87,88].

In the analysis of the intellectual structure, the science mapping or bibliometric mapping approach was used, a tool that provides a visualization of how the bibliometric analysis units, such as authors, documents, fields, and disciplines, are related [60].

In this study, various bibliometric methods are represented, and these methods allow for a visualization of the knowledge structure of Geoparks. For this purpose, influence and similarity measures used, with the support of the VOSviewer software, were: (i) bibliographic coupling (where the unit of analysis was the document, showing when two documents independently have cited the same article) [89–91], (ii) co-citation analysis (where the unit of analysis was journal and authors, showing a map of featured journals and authors that are linked by citation records) [92,93], and (iii) co-occurrence of keywords (with a network display map of author keywords, and with a minimum occurrence of those words) [68,69].

3. Results

3.1. Performance Analysis

3.1.1. Scientific Production Analysis

A total of 848 scientific documents met the exclusion and inclusion criteria, distributed between 2002 and October 2020. The Geoparks theme was divided into five groups according to the type of document: journal articles (524), which represent 61.79% of the total, followed by conference papers (234), book chapters (63), article reviews (23), and books (4) (see Figure 3).

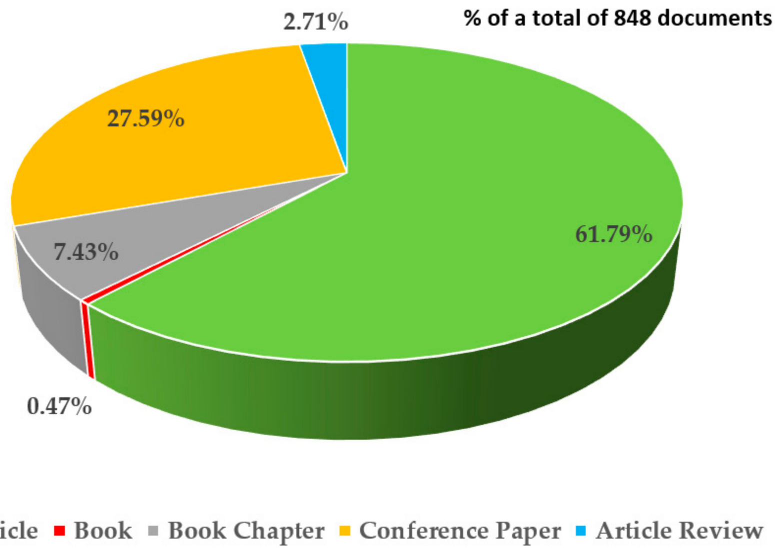
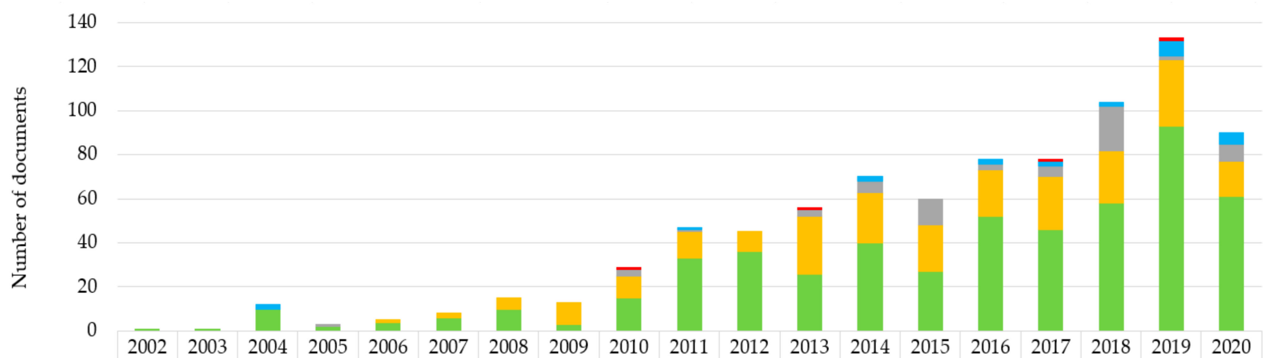


Figure 3. Percentage of publications associated with Geoparks in different document types.

Figure 4 presents scientific production and trends according to document type (2002–2020). The articles and conference papers show continuous growth as from 2010. Publications in 2020 registered a slight decrease, because collection information was carried out in the same year. The historical record of production shows that there is an opposite relationship between articles and conference papers in 2009. The number of articles decreased, while conference papers increased and doubled in relation to the previous year's production (2008).



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Book									1			1				1		1	
Article Review			2							1			2		2	2	2	7	5
Book Chapter				1					3	1		3	5	12	3	5	20	2	8
Conference Paper					1	2	5	10	10	12	9	26	23	21	21	24	24	30	16
Article	1	1	10	2	4	6	10	3	15	33	36	26	40	27	52	46	58	93	61

Figure 4. Articles, conferences papers, book chapters, article reviews, and books associated with geoparks published between 2002 and 2020.

Scientific production in the Geoparks field of study shows a growing interest on behalf of academia (see Figure 5), presenting 848 documents from 2002 to 2020. The analysis is divided into two periods according to the curve setting: the first period (2002–2009) and the second period (2010–2020).

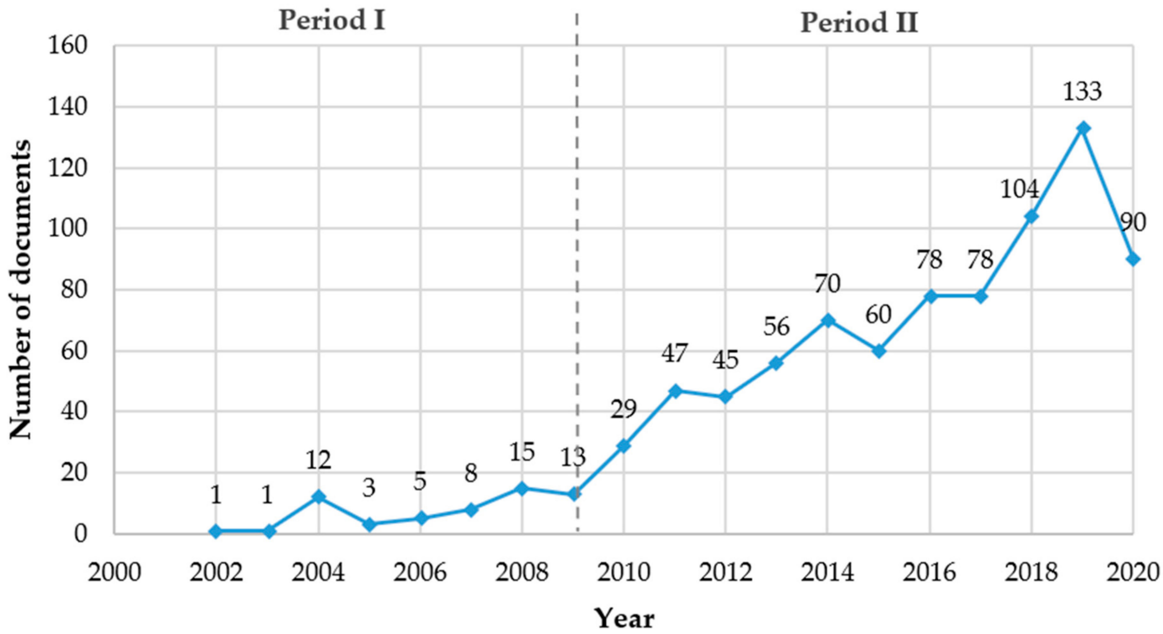


Figure 5. Growth of scientific production relating to Geoparks.

Period I (2002–2009): During this period, the growth of publications was moderate and did not exceed the global average of 45 works per year. The first article related to the study topic published in 2002 was 'National Geoparks initiated in China: Putting geoscience in the service of society' [94], written by authors Zhao and Wang in the journal Episodes, followed by the article published in 2003 by Zhao and Zhao [95] in the same journal.

In this period, 58 documents, representing 6.84% of the total production, were published. The most cited articles were 'Geodiversity: developing the paradigm' [96], published in 2008 by Gray, with 102 citations, followed by an article published in 2007 by Zouros [97], with a total of 86 citations in the journal Geographica Helvetica.

Period II: This period shows considerable growth. At the beginning, 29 documents were published. The most relevant is 'Public education in heritage conservation for geopark community', published in 2010 by Azman et al. [43] with a total of 36 citations in Procedia—Social and Behavioral Sciences, followed by an article published in 2010 by Joyce [7], with a total of 30 citations in the journal Geo-heritage.

The last three years saw a large number of publications, reaching 104 documents in 2018, 133 in 2019, and 90 documents during 2020. Highlights include an article review titled 'Geo-heritage, geo-tourism and the cultural landscape: Enhancing the visitor experience and promoting geo-conservation' [98] published in 2018 by Gordon, with 48 citations in the journal Geosciences (Switzerland), followed by 'Geo-heritage and geo-tourism' [5], published in 2018 by Newsome and Dowling, with 31 citations, as a chapter of the book Geo-heritage: Assessment, Protection, and Management.

In this period, 790 documents, representing 93.16% of the total production, were published. Among the most representative documents for number of citations are an article on the evaluation and inventory of sites of geological interest published by Brilha [99] in 2016, with a total of 239 citations in the journal Geo-heritage, and the article 'Geo-tourism's Global Growth' [10], published in 2011 by Dowling, with a quantity of 180 citations in the journal Geo-heritage.

The production of academic literature, especially in recent years, has shown that this subject is trending in the social and scientific community, an indication that Geoparks, through geo-tourism, achieve geo-heritage conservation and promote geo-education and sustainable development [100].

3.1.2. Contributions by Countries and Regions

The various countries' contribution makes it possible to link the knowledge and skills of researchers and their institutions [69]. Bibliographic coupling was used to quantify the references of a set of documents [86], specifically the countries involved. In the bibliographical coupling of countries, a threshold of at least one document per country was established; using VOSviewer, 68 countries reached the established threshold. Table 1 shows the top 15 countries according to the number of documents on the subject of Geoparks during the period 2002–2020.

Table 1. Top 15 countries by the number of documents.

Ranking	Country	Region	Documents	Citations	Links	Total Link Strength
1	China	Asia	188	905	61	10777
2	Indonesia	Asia	68	58	57	1971
3	Italy	Europe	68	300	58	8055
4	Poland	Europe	52	274	62	8148
5	Portugal	Europe	52	945	63	7541
6	Malaysia	Asia	49	200	56	2195
7	Spain	Europe	42	177	63	10952
8	United Kingdom	Europe	38	819	61	5830
9	Australia	Oceania	34	610	62	8475
10	United States	America	34	437	56	5875
11	Russian Federation	Europe-Asia	28	174	59	10352
12	Germany	Europe	27	150	56	3070
13	Japan	Asia	27	154	59	1853
14	Brazil	America	26	133	58	4801
15	Romania	Europe	25	70	54	2246

Figure 6 shows the bibliographical coupling analysis of countries, the most prominent nodes corresponding to China (188), followed by Indonesia and Italy (68) and Poland (52). The difference between the number of citations and documents by country is highlighted. The highest number of citations corresponds to Portugal (945), followed by China (905) and the United Kingdom (819). The countries are represented by nodes, and the size proportion is a function of the number of documents. The lines that join the nodes show the existing interconnection between countries; i.e., it shows the collaboration's strength.

Figure 6 shows 68 countries and 1519 links (relationships between countries) with a relationship strength of 75,674, grouped in eight clusters differentiated by colours; Table 2 shows the top three per cluster. The second cluster (green) contains the top 15 countries of this analysis, i.e., China (188), Italy (68), and the United States (34), and the eighth cluster (brown) is made up of two countries, Poland (52), which has a strong link with Spain (710) and Italy (657), and Lithuania (1), which has little collaboration with the other countries that contribute to the subject.

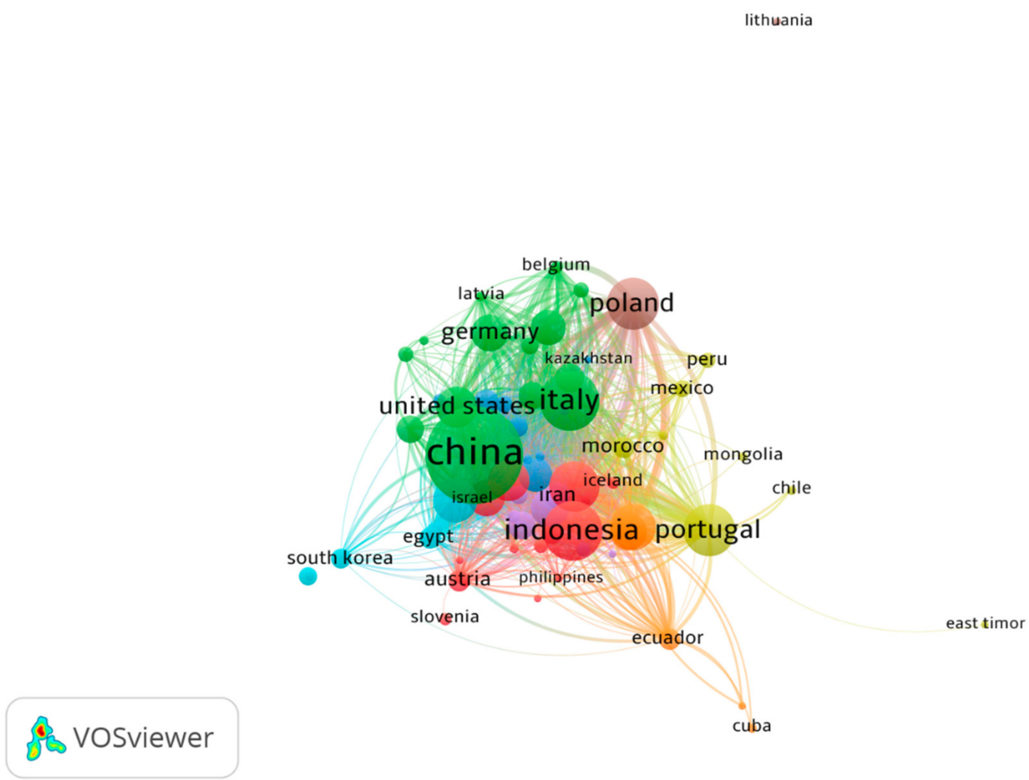


Figure 6. Bibliographic coupling of countries.

Table 2. Top countries per cluster by the number of documents.

Cluster	Documents	Citations	Links	Total link Strength	Author-Keywords
1	68	58	57	1971	Indonesia
Red	49	200	56	2195	Malaysia
(15 nodes)	34	610	62	8475	Australia
2	188	905	61	10777	China
Green	68	300	58	8055	Italy
(14 nodes)	34	437	56	5875	United States
3	22	162	58	3699	Czech Republic
Blue	12	322	50	1202	Greece
(11 nodes)	8	117	57	1634	Switzerland
4	52	945	63	7541	Portugal
Yellow	10	15	56	1845	Morocco
(8 nodes)	6	22	50	1083	Mexico
5	28	174	59	10352	Russian Federation
Purple	16	55	57	2282	Turkey
(7 nodes)	13	95	57	5185	Iran
6	38	819	61	5830	United Kingdom
Light Blue	9	66	58	4760	Egypt
(6 nodes)	8	45	52	604	South Korea
7	42	177	63	10952	Spain
Orange	26	133	58	4801	Brazil
(5 nodes)	9	19	61	2571	Ecuador
8 Brown	52	274	62	8148	Poland
(2 nodes)	1	1	1	2	Lithuania

3.1.3. Performance of Scientific Publications

The publications related to Geoparks have been distributed in different thematic areas. The principal analysis was carried out with emphasis on the five types of document (articles, conference papers, book, book chapters, and article reviews) considered in this study, which were published in 317 scientific sources.

Supplementary Materials Table S1 shows the 15 most published scientific sources according to the number of documents, representing 40% of the total. Additionally, performance indicators are presented: the H-index indicates both the productivity and the scientific impact of a journal [101], CiteScore is a measure that represents the total citations of a scientific journal in a specific year divided by the total number of publications cited during the last three years [87], Scimago Journal & Country Rank (SJR)shows the importance numerically of citations of the analyzed scientific journal, and the SNIP corrects the differences in citations between different fields of study [88].

Based on the number of documents, the journal Geo-heritage (Germany) leads the ranking (120 documents) in terms of addressing topics from Earth and Planetary Sciences, Environmental Science, and Social Sciences. This journal represents 14.15% of the 317 scientific documents on the subject of Geoparks. According to citations, the most relevant article was made by Brilha [99] in 2016, with a total of 239 citations.

The IOP Conference Series: Earth and Environmental Science, from the United Kingdom, with the theme of Earth and Planetary Sciences, ranks second (see Table 3). This source presents 34 publications, which corresponds to 4.01%. Ginting and Sasmita [102] published the most important article, which has five citations.

Finishing the top 3 is Rendiconti Online Societa Geologica Italiana, with the Earth and Planetary Sciences' subject area. This journal presents 30 publications, corresponding to 3.54%. The most notable article is by Cuomo and Guida [103], published at the 12th edition of the European Geoparks Conference held on September 4–7 in 2013 in Rome. The document presents a total of five citations.

According to the H-Index, the Canadian journal Episodes (67) stands out from the group. The most important article is 'The European Geoparks network', which has a total of 78 citations and was published by Zouros [104]. In second place is the international geoscience journal 'Proceedings of the Geologists' Association' (H-Index: 39) from the United Kingdom, highlighting its article 'Geodiversity: developing the paradigm' published by Gray [105] with 102 citations.

3.1.4. Frequently Cited Documents

When evaluating a field of study, it is necessary to consider documents based on the citations obtained [55]. The Geoparks scientific production (848 documents) presents 5571 citations. Table 3 shows the 15 most cited documents, which represent 1.77% of the total.

The most cited article is 'Inventory and Quantitative Assessment of Geo-sites and Geodiversity Sites: a Review', published in 2016 by Brilha, from the University of Minho, Portugal. This publication exposes various concepts related to geo-sites, geodiversity sites, and geo-heritage and provides a review of procedures in the inventory of sites at different scales. It proposes indicators to assess the risk of degradation in order to present guidelines for an adequate inventory of geodiversity, so as to aid in geopark strategies.

The article titled 'Geo-tourism's Global Growth' by Dowling [10], with an affiliation to Edith Cowan University, Australia, is located at Position 2 in Table 3. This publication addresses geological tourism (geo-tourism) and its nature, development, growth, and trends, and considers it a sustainable way for tourists to learn about geosciences and the multiple ways of viewing natural landscapes and their processes.

The article 'Geo-conservation as an emerging geoscience' [106] is the third most cited document. The publication deals with geo-conservation as an emerging science, recognizing its scope, methods, production, validation of knowledge, and its interrelations with other Earth sciences.

Table 3 also shows publications that are part of the 15 most cited documents on the subject of Geoparks.

Table 3. Top 15 most cited documents on the subject of Geoparks.

Ranking	Author	Year	Articles	Citations	References
1	Brilha J.	2016	Inventory and Quantitative Assessment of Geo-sites and Geodiversity Sites: a Review	239	[99]
2	Dowling R.K.	2011	Geo-tourism's global growth	180	[10]
3	Henriques M.H., dos Reis R.P., Brilha J., Mota T.	2011	Geo-conservation as an emerging geoscience	152	[106]
4	Hose T.A.	2012	3Gs for modern geo-tourism	134	[107]
5	Farsani N.T., Coelho C., Costa C.	2011	Geo-tourism and Geoparks as novel strategies for socio-economic development in rural areas	131	[108]
6	Gray M.	2008	Geodiversity: developing the paradigm	102	[105]
7	Newsome D., Dowling R., Leung Y.-F.	2012	The nature and management of geo-tourism: A case study of two established iconic geo-tourism destinations	92	[109]
8	Zouros N.	2007	Geo-morphosite assessment and management in protected areas of Greece—Case study of Lesvos island–coastal geo-morphosites	86	[97]
9	Zouros N.	2004	The European Geoparks network	78	[104]
10	Eder F.W., Patzak M.	2004	Geoparks–geological attractions: A tool for public education, recreation and sustainable economic development	76	[110]
11	Fassoulas C., Mouriki D., Dimitriou-Nikolakis P., Iliopoulos G.	2012	Quantitative assessment of geotopes as an effective tool for geo-heritage management	74	[111]
12	Gordon J.E.	2012	Rediscovering a sense of wonder: geo-heritage, geo-tourism and cultural landscape experiences	69	[112]
13	Prosser C.D.	2013	Our rich and varied geo-conservation portfolio: the foundation for the future	69	[113]
14	Zhang J., Li D., Li M., Lockley M.G., Bai Z.	2006	Diverse dinosaur-, pterosaur-, and bird-track assemblages from the Hakou Formation, Lower Cretaceous, of Gansu Province, northwest China	67	[114]
15	Kozłowski S.	2004	Geodiversity. The concept and scope of geodiversity	66	[115]

3.2. Intellectual Structure Analysis

3.2.1. Co-Occurrence Network of Author Keywords

One type of bibliometric analysis shows keywords and their connections, forming a network where those that appear most frequently in the field of study are displayed, and this allows one to examine concepts (keywords) and topics (grouped concepts) [60,116]. The analysis was made using VOSviewer, which enables multidimensional and visual representation [47,60]. A total of 1571 keywords were extracted from the database, 29 of which co-occurred in the documents at least five times. These various topics were found in six clusters (see Table 4). Figure 7 visualizes these six clusters, with 29 nodes, 149 links, and a total link strength of 629. The term 'geopark' presents 150 occurrences and a relationship with 27 terms; it is found in Cluster 5 (purple) as the most relevant word.

Table 4. Results of the co-occurrence network of author keywords.

Cluster	Co-Occurrences	Links	Total Link Strength	Author-Keywords
1 Red (12 nodes)	16	10	18	UNESCO Global Geoparks
	14	14	24	Tourism
	13	13	24	Conservation
	8	3	3	* GIS
	8	10	18	Heritage
	8	5	7	Sustainability
	7	9	10	Geology
	5	7	12	Education
	5	5	7	Heritage Conservation
	5	7	9	Local Community
	5	8	12	Management
	5	7	8	Planning
2 Green (4 nodes)	83	22	168	Geo-heritage
	58	18	117	Geo-site
	10	7	12	Karst
	6	6	18	Inventory
3 Blue (4 nodes)	44	16	96	Geo-conservation
	10	8	20	Geo-morphosite
	7	7	18	Geo-education
	6	7	10	SWOT Analysis
4 Yellow (3 nodes)	46	16	107	Geodiversity
	10	11	26	Biodiversity
	5	5	5	Geomorphology
5 Purple (3 nodes)	150	27	234	Geopark
	21	14	46	Sustainable Development
	5	4	7	Ecotourism
6 Light Blue (3 nodes)	124	27	214	Geo-tourism
	6	4	7	Sustainable Tourism
	5	1	1	Volcanic Geo-heritage

* GIS = Geographic Information System.

The most extensive research area according to the number of nodes is in Cluster 1 (red) (see Figure 7): 'Unesco Global Geoparks'. Researchers mention how Unesco Global Geoparks (UGG) propose events that can reinforce and develop citizens' knowledge about geosciences and promote unique geo-sites, cultural spaces, and critical historical processes, such as the innovative activities proposed in a ski event in the French Alps (UNESCO Chablais Global Geopark), to transmit knowledge of geographical heritage [117]. New fossil forests have been discovered in Greece and Hungary [118], and studies have emphasized that future studies are necessary to characterize the Laurinoxylon species from Oligo-Miocene Europe. A quantitative method has also been proposed to study the impact tourists have on geo-sites through a matrix of priorities [119]. Since a geopark is a holistic management project, further research is vital in this area. UGGs have geo-heritage as their central nucleus, which must be identified, evaluated, conserved, and adequately managed.

A global vision of the historical aspects, characteristics, and growth of this initiative was considered by Brilha in 2018 [9].

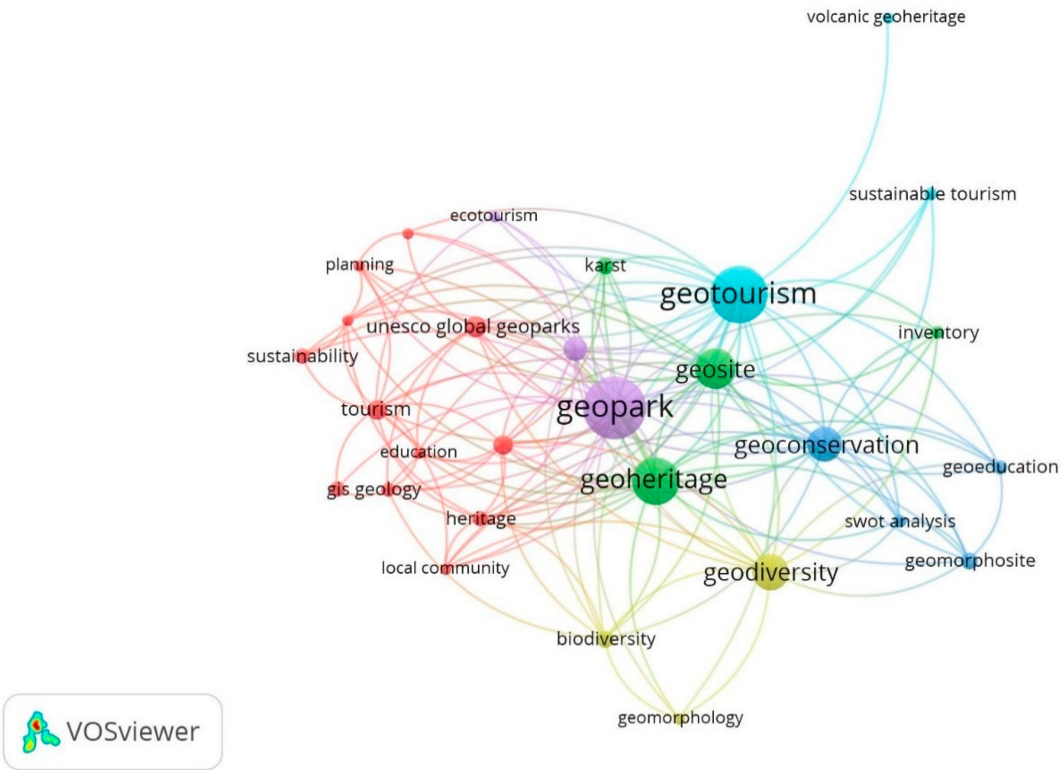


Figure 7. Co-occurrence network of author keywords.

New technologies based on geospatial analysis tools enable multitemporal analysis and use geomorphological cartography criteria. Multiple studies have been pursued, such as the valorization of geo-morphosites and geo-trails, mainly in mountainous environments [120], an exploration of factors influencing land cover and use due to geo-tourism development [121], an investigation of inhabitants' spatial affinity with the Geoparks, through processed cognitive maps combined with knowledge about the landscape values [122], and applications of Geographic Information System (GIS) in travel management and development [123].

The second research area is represented by Cluster 2 (green), 'Geo-heritage-Geosite'. The researchers emphasize the importance of assessing geologic heritage and its role as a comprehensive geo-conservation strategy [124]. It is necessary to evaluate sites to determine which of them favour geo-tourism development. A simple method of evaluation of geo-sites and geo-morphosites in Vizovická vrchovina Highland (Czech Republic) was used in Kubalíková and Kirchner [125]. Furthermore, a comparison of different quantitative geo-site evaluation methods was carried out in [126]. Brilha describes a Geo-site Conservation Generic Framework [3]. The author emphasizes that the site inventory should not be subjective. It must have a systematic methodology to follow and identify four pillars (subject, scale, value, and objective).

This cluster also highlights the karst phenomenon (especially caves and sinkholes, among others) as an essential and integral part of geo-heritage and Geoparks. The current state and biases in this area have been analyzed by Ruban [127]; the author identified the importance of karstic resources for geo-tourism development, especially when the number of geoparks is limited (e.g. Russia and the United States).

The third research area is Cluster 3 (blue), 'Geo-conservation-Geo-morphosite'. Geo-conservation is considered as an emerging geoscience. Its impact, scientific settings, different methodologies, validation, social relevance, and education for sustainable development were treated by Henriques [106]. A geo-site and geo-morphosite assessment method was used as a conservation tool; it had intrinsic, conservation and use-values as well as cultural and historical aspects linked to the natural environment [125]. The '8G' approach is a logical sequence that tries to explain its practical use in geo-tourism and geo-education [128]. It has also been used for SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats), a method commonly used for local development strategies, and for the evaluation of geo-tourism resources in several studies [31,32,39,125,129–132].

The fourth research area (Cluster 4, yellow) is 'Geodiversity–Biodiversity'. The inventories and evaluation of the elements of geodiversity can establish geo-conservation strategies promoting the development of Geoparks. A guide has been presented for geo-sites (sites with value scientific) and geodiversity site inventories [99]. A portfolio of geo-conservation sites, legislation, partnerships, and initiatives developed within the UK and internationally has been proposed by Prosser [113]. It includes geo-conservation audits, nationally protected sites, locally protected sites, internationally recognized sites, legislation relating to geo-conservation, geo-conservation policy and plans, conservation partnerships/groups/societies active in geo-conservation, geo-conservation publications, and examples of successful funding sources. Moreover, geo-conservation plays an essential role in determining biotic species [133] and provides a foundation for ecosystem services [134].

Origins, characteristics, comparisons with equivalents (biodiversity), points of maximum development, and examples of geodiversity hotspots such as Great Britain were explored by Gray [105]. Gray exhibited that a geopark and valuable geological elements such as geo-heritage can include other types of heritage, such as biological and cultural. The term 'Bio-site' [135] relates to places with endemic species of both flora and fauna and where it is necessary to establish conservation measures in a Geopark.

On the other hand, knowing and understanding the processes that gave rise to the geomorphology and landscape of territories are of interest in Geoparks, since they promote a sense of place and the revitalization of communities. Geomorphological mapping is a starting point for many applications and the realization of thematic maps that range from hazard and risk maps to geo-heritage and geo-tourism maps. 'Geomorphological Boxes' are shown as an example of education practices in Geo-Risk [120], a tool for interpreting geographical features and their dynamics in a didactic way.

The fifth research area, represented by Cluster 5 (purple), is 'Geopark-Sustainable Development'. Researchers show that, despite infrastructure, site hardening, and interpretations of iconic geo-sites, visitors' sustainable management can be a significant challenge, as presented in examples of geo-sites in Taiwan and Australia [109]. Investigations were carried out in different Geoparks by Farsani [23,108], studying how the Geopark model includes the community in its conservation practices, exposes geological knowledge, generates job opportunities to improve quality of life, and evaluates innovative Geopark strategies for the sustainability of these social sectors [136]. A key aspect of sustainability and conservation strategies is education in geosciences at primary level. The general ignorance of geological heritage value is an obstacle to preserving the abiotic resources of our planet [137]. Geo-conservation requires trails (geo-trails) in the Geoparks, which can allow tourists to observe the geo-heritage [138] and contribute to environmental sustainability.

With the growth of Geoparks, tourism that focuses on geological elements (geo-tourism) is beginning to promote sustainable development, but according to Newsome [109], if it is not handled correctly, it can pose a direct threat to geological heritage resources. An example of a geopark in this context is the Beigua Geopark (Italy) studied by Burlando [139]. Its practices connect nature, culture, and recreational activities with distinct geological elements and simultaneously sensitize the public to nature conservation.

Geoparks are holistic, since the geological, landscape, ecological, climatic, oceanographic, and anthropogenic aspects of the environment mutually influence each other. Ecotourism contributes to conservation work and make geo-tourism activities more attractive to those interested in ecotourism or nature-based tourism products. The development of ecotourism products in geoparks and the perceived satisfaction of tourists was studied by Jaafar [140].

The sixth research area is 'Geo-tourism-Sustainable Tourism'. Geo-tourism is sustainable tourism that focuses on geological characteristics, landscapes, and tourist visits; it has been an indispensable factor for developing geoparks [10]. Hose [107] considered the existence of three interrelated elements of geo-tourism: geo-conservation, geo-history, and geo-interpretation. There is a correlation between geoparks and geo-tourism [141]. Ólafsdóttir assessed geo-conservation and rural development strategies within geo-tourism and focused on the fact that, in environments as vulnerable as the case study from Iceland, and in general, it is essential to strike a balance between conservation, geodiversity, and sustainable tourism [142]. The type of geo-heritage linked to volcanic and geothermal environments, as well as examples of geo-tourism practices, were studied and evaluated by Erfurt-Cooper [143]. In recent years, the recognition of volcanic geo-heritage has given rise to many geo-heritage, geo-conservation, and geo-tourism studies [144–148]. Volcanoes are of particular interest and attract many tourists each year [149].

3.2.2. Cited authors Co-Citation Network

This kind of study enables the recognition structure of a research field, yielding the most active areas of study, the emerging trends, or the means of disseminating knowledge [47,150]. The analysis emphasizes outstanding authors, which are linked using citation records [68,93].

The construction of the proposed bibliometric network was, with VOSviewer, carried out using a measure of similarity called association strength to analyze data related to co-citations [60]. The Geoparks information base has 31,357 cited authors, 206 of which presented at least 20 citations. In Figure 8, the author co-citation map shows 11 clusters, 206 nodes, 12,121 links and a total link strength of 4632.95. The 15 most cited authors are shown in Table 5.

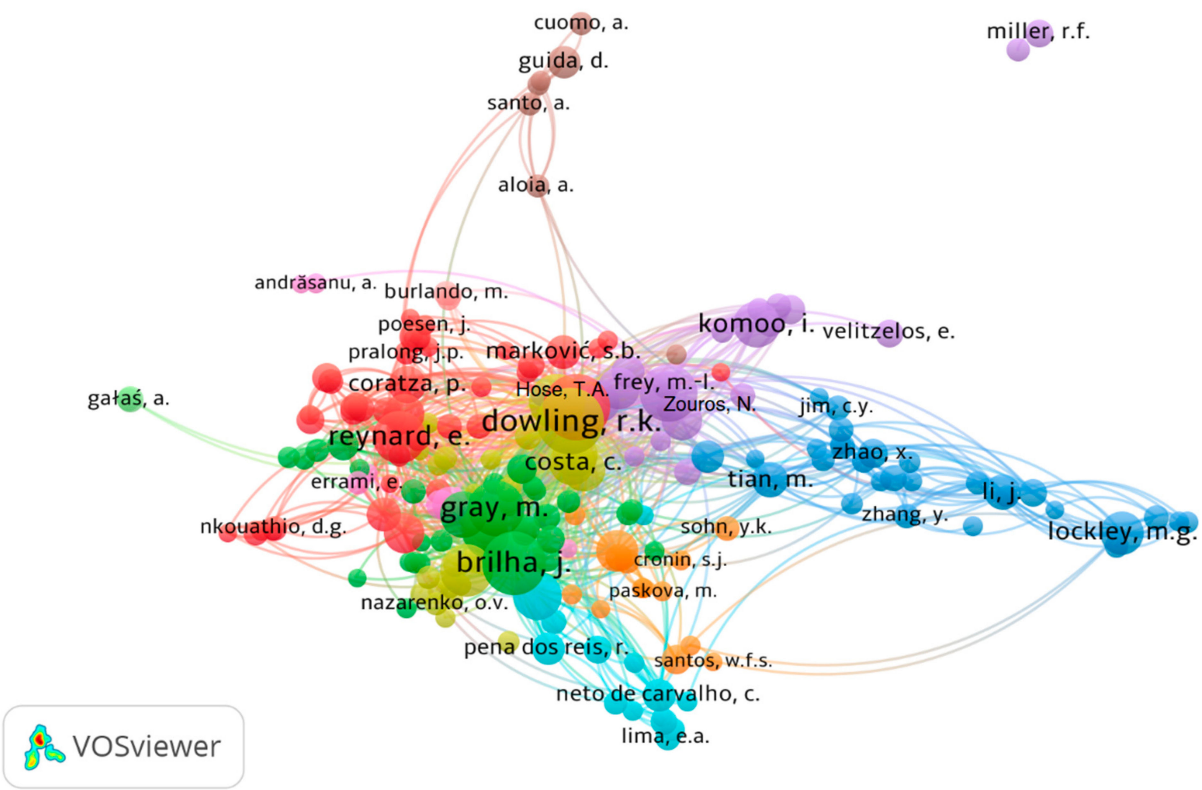


Figure 8. Authors' co-citation map.

Table 5. Top 15 authors co-cited in references on Geoparks.

Ranking	Authors	Co-Citations	Links	Total Link Strength
1	Dowling, R.K.	386	194	347.7308
2	Hose, T.A.	371	187	307.287
3	Brilha, J.	332	197	306.0376
4	Zouros, N.	266	191	234.0087
5	Newsome, D.	249	189	233.1951
6	Gray, M.	242	189	225.1668
7	Reynard, E.	224	194	210.608
8	Ruban, DA.	220	179	194.8632
9	Henriques, M.H.	175	191	152.2053
10	Wimbledon, WAP.	156	178	116.5509
11	Komoo, I.	156	159	145.1209
12	Costa, C.	151	192	145.7539
13	Coelho, C.	147	192	143.3703
14	Gordon, J.E.	143	176	129.955
15	Prosser, C.D.	141	180	133.06

This section examines the intellectual structures of the Geoparks field generated by the different approaches to author co-citation using network analysis. Cluster 1 (red), 'Geo-tourism–Geo-site–Geo-morphosite', comprises 43 authors (nodes), led by Hose (371), Reynard (224), Panizza (113), Pereira (111), and Coratza (92). During the period 2001–2012, progress was made in research related to geo-morphosites or geomorphological sites studied by Reynard [151], who exposed specific characteristics linked to an overlapping dynamic aesthetic dimension. The scientific literature shows a development of methods to evaluate the specificities of geomorphological heritage and take scientific and additional values into consideration [152,153]: scientific, use, and protection values [154] and scientific, additional, use, and protection values [155,156]. The concept of geo-tourism [157–160] and important aspects in modern geo-tourism, such as the key '3G' aspects related to geo-history, geo-conservation, and geo-interpretation [107], have been treated by the researcher leading this cluster.

Cluster 2 (green), 'Geo-diversity–Geo-heritage–Geo-site–Geo-conservation', consists of 38 nodes, where the most outstanding authors are Brilha (332), Gray (242), Wimbledon (156), Gordon (143), and Prosser (141). Specifically, Brilha [99] proposes new geo-site and geodiversity site concepts based on scientific values and determines whether a site is in its natural habitat or has been dislodged. The author also developed a quantitative method for an assessment and inventory of geo-sites and geodiversity sites applied at different scales, considering scientific, educational, and touristic criteria to evaluate the risk of degradation [161].

Gray showed the theory and values of geodiversity and its application to geo-conservation [1] and concluded that geodiversity is the backbone of geological heritage, geo-conservation, and modern society itself [162]. Gray highlights that the geology–tourism link is economically important, but it can cause damage to biodiversity and geodiversity [1]. Other researchers such as Prosser have described basic concepts and practices and have presented a portfolio for geo-conservation science and society [113,163–165]. Gordon [112] examined geodiversity through the contributions of the arts (poetry and literature) and the relationship between the environment and people. Wimbledon and Smith [166] state that geological heritage conservation has been changing through recent protection initiatives in most European countries. That is why the protection of geo-sites is becoming a profitable activity and is capable of creating new jobs and generating economic and social development. In general, the researchers in this cluster expose the importance of geodiversity and its value in meeting the social demands made by a community [167–169], such as environmental awareness and changes related to climate and tourism [167].

Cluster 3 (blue), 'Palaeontological Record-Geopark', consists of 30 nodes led by the authors Lockley M.G. (133), Tian M. (91), Li J. (83), Wang, L. (67), and Zhao X. (44). It is a growing interest in relation to paleontological records, especially the geo-conservation of dinosaur track sites. One such example is the newly discovered dinosaur footprints at the

Yanqing Silicified Wood National Geopark [170]. Authors from this cluster have provided several case studies, including dinosaur ichnotaxonomy from China, as well as theropod, ornithopod, and prosauropod footprints sauropods often associated with bird footprints in the Cretaceous [114,171,172]. They also address the history of science and the relevance of the ichnology of dinosaurs [173].

Cluster 4 (yellow), 'Trends and growth of the Geo-tourism–Geo-diversity–Geo-park', comprises 26 nodes led by researchers Dowling (386), Newsome (249), Ruban (220), Costa (151), and Coelho (147). Dowling describes the relationship of geo-tourism with other areas of knowledge related to tourism (cultural tourism, ecotourism, or adventure tourism) and its development, growth, and trends and considers geo-tourism as fundamental for the formation of geoparks related to UNESCO [10]. Dowling and Newsome, in their book 'Geo-tourism' [174], summarize five essential points of geo-tourism: (i) there is no generally accepted definition of geo-tourism; (ii) practically all countries have some geological resources with a potential for geo-tourism development; (iii) the impacts of geo-tourism are not yet well understood; (iv) tourists will accept geo-tourism if they interpret it properly; (v) the geopark initiative has the potential to promote geo-tourism at community, regional, and national levels.

Ruban proposes mathematical expressions for the quantitative evaluation of geodiversity, geo-abundance, geo-richness, and geodiversity loss [175] and shows how Geoparks are ideal tools for the exploitation of geodiversity resources. It is emphasized that more research is needed into the legal instruments that regulate the establishment of Geoparks and greater participation from the UNESCO's National Commissions [44].

Other researchers in this group analyze the role of Geoparks in creating jobs and developing new products and services in the local economy, considering that geo-tourism is a niche market. Therefore, geo-tourism is in an initial stage commercially [108]. Additionally, geoparks are essential in the conservation and management of geo-knowledge, since they involve local communities in managing knowledge and preserve geoparks as new tourist attractions [23], and in cultural sustainability in rural areas [136].

Cluster 5 (purple), 'UNESCO Global Geopark-Geo-tourism', consists of 22 nodes led by the authors Zouros (226), Komoo (156), Patzak (127), Eder (120), and McKeever (95). The authors of this research describe the development of the European network of Geoparks in order to promote geological heritage for the development of the community where they are located [104]. UNESCO has played a fundamental role in promoting the European model to other Geoparks around the world [176].

The Geopark idea is analyzed in detail showing the fundamental features, application processes, and benefits in geological areas and in local communities [42]. Geoparks are becoming increasingly popular globally and are used to promote education and geo-tourism, whose purpose is sustainable development [104,110,177,178].

Cluster 6 (light blue), 'Geo-conservation-sustainable tourism development', consists of 14 nodes led by the authors Henriques (175), Neto De Carvalho, C. (72), Pena Dos Reis (69), Sa (47), and Nunes (42). Researchers from this group highlight geo-conservation as a new body of scientific knowledge and deep social interrelation because it provides the necessary knowledge to solve environmental problems that afflict society, such as poor land-use planning overexploitation of geological resources, and protection and sustainability of nature [106], and differentiate three types of geo-conservation related to geo-heritage: primary, applied, and technical applications. Furthermore, they promote scientific education involving Earth Sciences, through geo-conservation, that is supported by a legal framework that ensures the implementation and protection of natural areas.

Neto de Carvalho highlights how the growth of pedestrian trails in the nature tourism market, including Geoparks, is setting a trend due to its ability to connect the local culture with the most remote and fascinating places on Earth. An example is the 'Fossils Trail', which shows the iconic heritage of the Penha Garcia Ichnological Park, and has won awards from international associations such as The European Association for the Conservation of Geological Heritage (ProGEO) and National Geographic. The construction of the Geopark allows its visitors to understand the marine life of the Cambrian period [179,180].

Geo-tourism is used as a conservation tool in the Azores archipelago [181,182]. Some examples in the Azores Geopark include products based on geo-tourism for the general public and specialized groups. For the former, there are outdoor activities such as geo-tours and walking trails and the possibility of knowing in depth the benefits of the Geopark through diving and snorkeling. For specialized groups, there are activities related to volcano-speleology and climbing (rocks and mountains). Additionally, there are geo-products: wines, cheeses, and typical dishes cooked with an earth oven [181].

Cluster 7 (orange), 'Volcanic Geo-heritage–Ichnological Geo-heritage', encompasses 14 nodes led by the authors Nemeth (126), Carvalho (58), Moufti (46), Sohn (37), and Kereszturi (35). The members of this cluster have aroused general interest in volcanism using a geo-touristic approach, promoting the investigation of volcanic geo-heritage from the aspects of tourism and volcanic research. The volcanic geo-sites of the unique intra-continental monogenetic volcanic field found in Harrat Al Madinah Volcanic Geopark (HAMVG) are presented in Moufti [183].

Additionally, researchers from this group show the geo-educational potential of maars and tuff rings in arid environments and how they demonstrate the internal and external processes involved in this type of volcanism [184]. Studies of the peculiarities of the eruptive styles, lithological characteristics, and geomorphic architectures of monogenetic volcanism have been presented [185–189].

Vertebrate ichnology has achieved some notoriety through prominent dinosaur tracks. Dinosaur tracks and trackways found in basins in Brazil are examples of the palaeontological heritage of the area [190–194]. Some authors of this cluster have proposed geo-conservation plans [195,196] and an inventory and assessment of sites of paleontological interest in the Sousa Basin (Paraíba, Brazil) [195], and some scientific contributions are associated with the origin and preservation of Sousa Basin dinosaur footprints [197] and the characteristics of the various species of dinosaurs found in this region [193,198].

Cluster 8 (brown), 'Geo-tourism in Karst System', consists of seven nodes led by the authors Guida (68), Aloia (34), Cuomo. (32), Santo (31), and Santangelo (26). The members of this cluster highlight how geo-tourism promotes conservation and geo-education in karst areas. The authors of this research area have carried out hydro-geomorphological studies and hydro-chemical monitoring activities in Southern Italy in Cilento, Vallo di Diano, and the Alburni UNESCO Global Geopark [199–207]. Studies have been done on the 'Middle Bussento Karst System', the second-longest karstic system in Italy [208], and on geo-sites and geo-tourism in Southern Italy [209,210].

Cluster 9 (pink), 'Geo-heritage, Geo-conservation, and Geoparks in Africa and The Middle East', comprises seven nodes led by researchers Semeniuk (83), Brocx (57), Errami (30), Andrăşanu (24), and Seghedi (21). Although most geopark research is concentrated in Europe, the researchers of this cluster have proposed examples developed in these regions, and other aspirants, to the UNESCO initiative [211]. Brocx and Semeniuk [212] proposed a 'Geo-heritage Tool-kit' consisting of five steps toward the evaluation of geo-conservation types, which aids in the identification of geological regions and in the determination of the levels and types of geo-conservation required.

Specifically, Andrăşanu addresses, in general terms, the concept of a Geopark, highlighting its innovative approach, and this concept has multiple valences [213]. The author proposes SEA and Big-S models that consider three values: Science, Education, and Aesthetics, which can assist in geo-site management considering the tourist impact [214].

Cluster 10 (coral), 'Geopark-Sustainable Development', includes three nodes led by the authors Burlando (35), Firpo (31), and Queirolo (25). The authors of this cluster describe how Geoparks, with the help of geo-tourism, have become vehicles to promote sustainable development, as in the Beigua Geopark [139,215,216]. The Geopark provides visitors with a series of sustainable tourism practices such as the Geopark Trails Network, interpretation facilities, and Info Points [139] that promote knowledge of the local geological, biological, cultural, and historical heritage.

Cluster 11 (light green), 'Peruvian Volcano geo-heritage', consists of two nodes led by the authors Gałaś (41). and Paulo (31). It presents a series of investigations carried out in Peru by Polish scientists. This enabled a proposal for a Geopark in the region that contains one of the deepest canyons in the world, located in the Colca region, known as the 'Valley of the Andagua Volcanoes' [29,217], a place full of geodiversity and that hosts a variety of lava domes and scoria cones [218].

3.2.3. Scientific Source Co-Citation Network

This analysis contemplates a direct observation of the journals that have been cited many times within the field of study's structure, complementing previous analyses [219]. The most active and influential scientific sources for Geoparks were identified using VOSviewer. A threshold of a minimum of 20 citations was established, which allowed 60 scientific sources to be considered. Table 6 shows the top 15 scientific sources co-cited on the subject of geoparks.

Table 6. Top 15 scientific sources co-cited on Geoparks.

Ranking	Scientific Source	Co-Citations	Links	Total Link Strength
1	Geo-heritage	908	59	10614
2	Episodes	246	58	2834
3	Proceedings of The Geologists' Association	191	57	3183
4	Geomorphology	155	50	1957
5	Tourism Management	129	37	1344
6	Journal of Volcanology and Geothermal Research	128	41	3301
7	Nature	87	54	1056
8	Quaternary International	86	55	1850
9	Journal of African Earth Sciences	83	43	1474
10	Annals of Tourism Research	79	27	1024
11	Geology	75	48	1018
12	Tectonophysics	72	52	1137
13	Catena	66	47	1193
14	Geosciences	62	48	1027
15	Geological and Landscape Conservation	59	35	687

Cluster analysis divided a group of heterogeneous populations into subgroups with higher similar properties. The journal co-citation map, shown in Figure 9, is represented by six clusters, 60 items, and 1138 links, with a strength of 28,020.

Cluster 1 (red), 'Geodiversity–Geomorphology', comprises 17 nodes led by the journals Geomorphology (155), Nature (87), and Geology (75). Cluster 2 (green), 'Geo-conservation', consists of 10 nodes headed by the journals Quaternary International (86), Catena (66), and Chinese Science Bulletin (38). Cluster 3 (blue), 'Geology–Geo-tourism', comprises nine nodes led by the journals Proceedings of The Geologists' Association (191), Geological and Landscape Conservation (59), and Geo-tourism (59). Cluster 4 (yellow), 'Tourism–Geo-tourism', comprises nine nodes, where the leading three are dedicated to tourism management issues, the first being 'Tourism Management' (129), followed by 'Annals of Tourism Research' (79) and 'International Journal of Tourism Research' (55). Cluster 5 (purple), 'Geo-heritage–Geopark', comprises six nodes led by the journals Geo-heritage (908), Episodes (246), and Journal of African Earth Sciences (83). Cluster 6 (light blue), 'Volcanic Morphology–Geo-heritage', comprises three nodes led by the journals Volcanology and Geothermal Research (128), Bulletin of Volcanology (59), and Geological Society of America Bulletin (42).

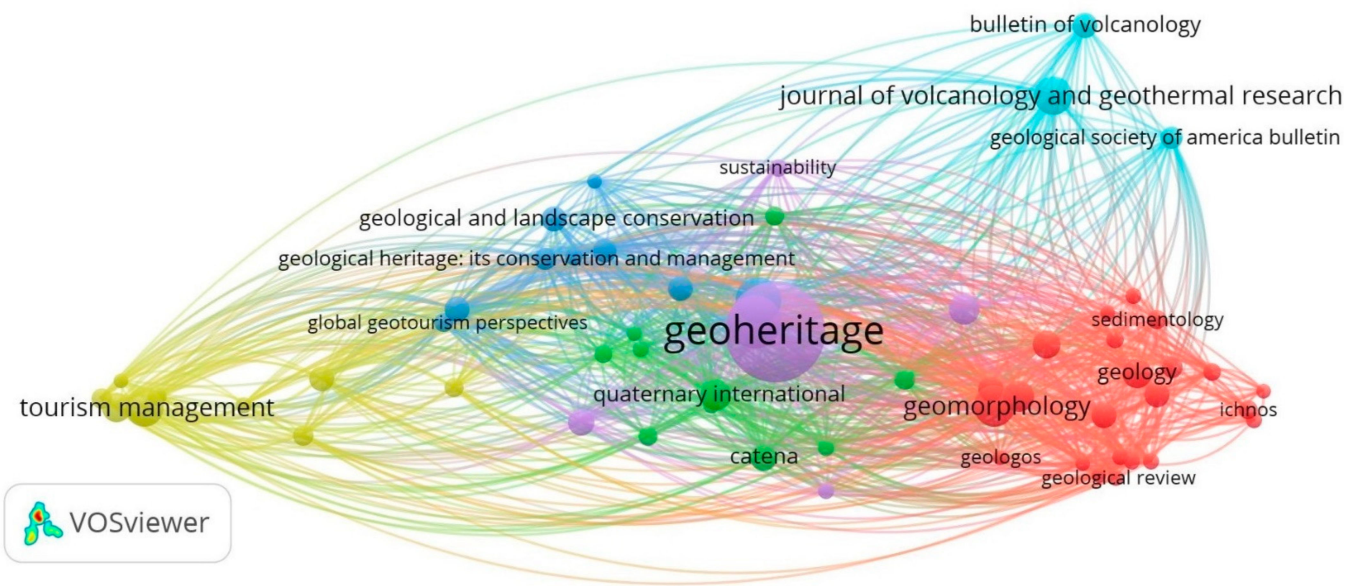


Figure 9. Scientific source co-citation network.

4. Discussion

To maintain a pact between nature and man, international designations have been created, such as the concept of 'Biosphere Reserves' [220], which began in the mid-1960s, focusing on combining the functions of conservation, sustainable development, and logistical support for all forms of life in an ecosystem. From the first 57 Biosphere Reserves in 1976, their number has increased considerably to 714 sites, currently distributed in 129 countries [221], whose total area is comparable to the size of Australia. 'World Heritage' began in November 1972 with the convention "Concerning the Protection of the World Cultural and Natural Heritage" [222], whose purpose was to ensure the protection of places that maintain a cultural legacy or unique natural characteristics, and even to provide emergency assistance to sites in potential or imminent danger.

Although these designations planted a seed for a kind of protection of natural diversity, if the list of world heritage sites is analyzed, it is identified that, of the 1121 declared sites, more than 75% are cultural sites (869) and natural sites (213), a low number of which contain geological heritage of international importance [223]. Similarly, the areas designated as 'Biosphere Reserves' that have mostly concentrated in Europe and North America highlight the biotic part of geographical areas. The Geoparks concept is an integrating system that is relevant to geology or geodiversity, including biodiversity and cultural diversity in a territory, and provides education, conservation, and geo-tourism and community development. The analysis of scientific production in this study began in the 21st century, which coincides with the signing of the Almería cooperation agreement of UNESCO in 2001 [19]. Two periods are clearly defined (see Figure 5): 2002–2009, which did not reach an average of 45 publications per year, and 2010–2020, which saw exponential growth and represents 93.16% of the total scientific production on the subject.

Based on the geographical distribution of the sites named "UNESCO Global Geoparks" [21], a geographic pattern was identified mainly in Europe and Asia. This pattern was repeated when performing the bibliographic coupling of countries (see Table 1 and Figure 6). China has contributed most in the field according to the number of scientific publications, followed by other countries in Asia and Europe (e.g., Indonesia, Italy, and Poland), the United States (which occupies position #10) and Brazil (position #14), being the only countries in America within the top 15. The United States does not have areas officially recognized as Geoparks, and Brazil, in 2006, was the first country in Latin America to achieve such a denomination, with the Araripe Geopark [27].

Furthermore, according to the intellectual structure analysis (see Figure 7), the topics most mentioned in this academic field are 'Geopark', 'geo-tourism', 'geo-heritage', and 'geo-site'. The word 'Geopark' (Cluster 5) has strong links with 'geo-tourism' (Cluster 6) and 'geo-heritage' (Cluster 2). Geo-tourism contributes to the bottom-up approach of the Geopark concept [22] through the use of geological values as economic resources in these areas. Newsome [109] considers it a potent instrument of sustainable development; that is, it promotes not only natural conservation but also generates positive impacts in the different areas of the Geopark, which, in addition to bringing benefits, can also harm the geological heritage without established management strategies. One means of geo-conservation is the assessment of geological heritage [124].

The evaluation of geological heritage has aroused many researchers' interest, including Brilha [99], who has exhibited one of the most representative works in the field of study and has a high number of citations (239). This work establishes essential differences in the definition of geo-sites and geodiversity sites, and a quantitative geo-site evaluation methodology. However, geomorphological sites have become a commonly approached topic, which is an active area of research (see Figure 8, Cluster 1, red) and includes a study of the advances and characteristics of geo-morphosites [151], in addition to a series of methods to evaluate them [152–156].

Figure 8 shows that certain lines of research have been incorporated into Geoparks, e.g., Cluster 7 (orange), 'Volcanic Geo-heritage–Ichnological Geo-heritage', especially studies regarding volcanic structures, tuff rings, and maars [184], the characteristics of monogenetic volcanism [185–189], and vertebrate ichnology, which has led to several case studies related to dinosaur tracks and trackways as examples of palaeontological heritage [190–194]. Another emerging line is Cluster 8 (brown), 'Geo-tourism in Karst System'. This type of relief formed by the chemical precipitation of carbonate rocks has led to investigations of the karst environment; e.g., its hydrological and hydrogeological characteristics have been an object of study in the Cilento, Vallo di Diano, and the Alburni geopark of Italy [199–207]. Karst systems are vulnerable to contamination, constitute a geological element with significant geo-tourism value, and can contribute to the environmental awareness of this type of geo-resource [223].

One of the best ways to become aware of geodiversity is the development of initiatives for Geopark projects [31–39], which are booming and integrates geodiversity [2], aspects or characteristics of biodiversity [133–135], and the inhabitants [224] of a territory. Thus, an environment for education, research, and geo-tourism is established, considering geo-conservation as a bolus [125,142]. Geo-tourism becomes a new type of tourism framed under the banner of sustainable tourism [6]. Currently, faced with a pandemic, geo-tourism has greater possibilities of offering protocols and security guarantees to people [225] that ensure health criteria for human beings and geo=conservation for nature.

Concerning this study's methodological approach, it has two main limitations: using a single database (Scopus) and a single language (English), which, despite being the majority language, may exclude significant contributions in other languages. However, the bibliometric approach applied is rigorous and reliable and has been used by researchers around the world in various studies, including [72,226,227] among others. The study required the use of descriptors related to the term Geopark to obtain information in the study field. These descriptors are subject to a triangular search (title–abstract–Keywords), considering that the title of the manuscript allows identification of the central focus of the research and the importance that the authors give to the subject, which can be complemented with the use of the abstract and keywords that allow expansion of this focus when considering related research with the term. This procedure allows the addressing of the entire structure of the field of study.

5. Conclusions

This study provides a bibliometric analysis of scientific publications related to Geoparks, indexed in one of the online databases recognized in the academic world, the Scopus database, dating from 2002 to October 2020. A total of 848 documents met the rigorous selection criteria of bibliometric analyses. The first record from 2002 is entitled 'National Geoparks initiated in China: Putting geoscience in the service of society' by authors Zhao and Wang in the journal Episodes. The greatest amount of scientific production was found in 2018–2019 with 104 and 133 publications, respectively. The most cited article is 'Inventory and Quantitative Assessment of Geo-sites and Geodiversity Sites: a Review' written by Brilha in 2006, with 239 citations.

In the study of Geoparks, scientific production corresponds to journal articles (61.79%) and conference papers (27.59%). Production is centred in the continents of Europe and Asia, with China presenting itself as the central producer with 188 publications and 905 citations. Based on the number of citations, Portugal stands out with 945 citations and 52 documents. These publications are distributed in 317 scientific sources, of which the journal Geoheritage' leads with 120 documents and 1742 citations and has a CiteScore of 3.9. When considering the H-Index, the Episodes journal has a value of 67.

The intellectual structure of Geoparks needs to be considered. First, the network of co-occurrence of author keywords is represented by six clusters and 29 nodes, where the term Geopark has 150 occurrences relating to 27 terms. The clusters were named 'Unesco Global Geoparks', 'Geo-heritage–Geo-site', 'Geo-conservation–Geo-morphosite', 'Geodiversity-Biodiversity', 'Geopark-Sustainable Development', and 'Geo-tourism–Sustainable Tourism'. The most relevant area is formed by Cluster 1 ('Unesco Global Geoparks'), highlighting how Geoparks improve rural communities' economic situations through the conservation of natural heritage and, in turn, favour geoscience education and the development of tourism practices with environmental sustainability. Further research on the management of impacts on geo-sites is necessary to integrate the holistic concept that drives Unesco Global Geoparks.

Second, the author's co-citation network includes 11 clusters that represent the various topics related to Geoparks: 'Geo-tourism–Geo-site–Geo-morphosite', 'Geodiversity–Geo-heritage–Geo-site–Geo-conservation', 'Palaeontological Record-Geopark', 'Trends and growth of the Geo-tourism–Geodiversity–Geopark', 'UNESCO Global Geopark–Geo-tourism', 'Geo-conservation–sustainable tourism development', 'Volcanic Geo-heritage–Ichnological Geo-heritage', 'Geo-tourism in Karst System', 'Geo-heritage, Geo-conservation', 'Geoparks in Africa and The Middle East', 'Geopark–Sustainable Development', and 'Peruvian Volcano geo-heritage', where the most significant cluster is Cluster 1, 'Geo-tourism–Geo-site–Geo-morphosite', consisting of 43 nodes (thematic) and led by Hose.

Third, the network of co-citations of scientific sources is represented by six clusters, demonstrating the fields of knowledge that the field of geoparks has developed: 'Geodiversity–Geomorphology', 'Geo-conservation', 'Geology–Geo-tourism', 'Tourism–Geo-tourism', 'Geo-heritage–Geopark', and 'Volcanic Morphology–Geo-heritage'. The Geo-heritage journal is strongly linked to most scientific sources.

Finally, it is necessary to consider that the analysis of the intellectual structure allowed us to define certain aspects:

(i) There is a growing concentration of research on geomorphological heritage and geo-tourism, and this research focuses on methodologies that evaluate the specialities of this type of heritage with different methodological approaches and tries to define the concept of geo-tourism; there is a great interest especially in the evaluation and identification of geo-sites/geo-morphosites and in trying to eliminate subjectivity of method.

(ii) Research areas such as 'Geo-tourism in Karst System' are considered a type of geo-heritage with potential geo-tourism development due to its high cultural, historical, and recreational value and its unique geological and hydraulic structure, especially in countries such as Russia and the United States, where the number of active UNESCO global geoparks is scarce. There is concern that karst environments are vulnerable points of contamination, making it difficult to protect and manage them in a sustainable way.

(iii) The protection of geo-sites/geo-morphosites is becoming a profitable activity, capable of creating new jobs (geo-products, geo-menus in restaurants, geo-tours, geo-restaurants, geo-bakeries geo-sports, and geo-monuments, among others) and stimulating economic and social development.
(iv) Geo-tourism is an integral part of UNESCO Geoparks and is an example of niche marketing, a hidden opportunity that it is in an initial stage commercially.
(v) Researchers have provided a series of case studies on vertebrate ichnology in Geoparks, especially on dinosaur tracks and trackways.
(vi) Volcanism has been studied using a geo-touristic approach. In particular, given the eruptive styles associated with monogenetic volcanism, the geo-educational potential of maars and tuff rings, and how they help to distinguish the internal and external factors that shape the various eruption styles of these short-lived, small-volume monogenetic volcanoes, has been highlighted.
(vii) Although most Geopark research is concentrated in Europe and Asia, scientists in Africa, the Middle East, and Southern Peru, an area that is home to the Colca Canyon and the Valle de the Andagua Volcanoes, one of the deepest canyons in the world, have also shown interest in geo-heritage.

Additionally, it is necessary to consider that this research has certain limitations: (i) besides the use of the Scopus database, other databases used in the academic world such as the Web of Science or Dimensions were not used; (ii) publications in other languages were not considered, so some contributions in the field were ignored. Later studies may consider these limitations in order to broaden the subject matter dealt with in this research. The rigorous bibliometric process presented, the selection of critical descriptors to identify the field of study and the extensive analysis proposed consolidates a point of reference for future research in the Geoparks area.

Supplementary Materials: The following are available online at https://www.mdpi.com/2071-1050/13/3/1175/s1, Table S1. The Top 15 most published scientific sources in geoparks.

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