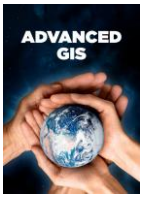
Advanced GIS

http://publish.mersin.edu.tr/index.php/agis/index

e-ISSN:2822-7026



Evolution and future trends in global research on geographic information system (GIS): a bibliometric analysis

Mert Kayalık [1], Osman Sami Kırtıloğlu [1], Zeynel Abidin Polat*[1]

[1]*İzmir Katip Çelebi University, Faculty of Engineering and Architecture, Geomatics Engineering, İzmir, Türkiye*

Keywords
GIS,
Bibliometric Analysis,
Social Network Analysis,
Scopus,
VOSviewer

Research Article
Received:17/03/2023
Revised: 28/03/2023
Accepted: 31/03/2023
Published: 06/04/2023

ABSTRACT

In this article, the global research status and future trends of GIS are examined using bibliometric analysis. This study is based on an analysis of the most cited articles on GIS research topics, scientific production, collaboration between countries and authors, and GIS research from the Scopus database from 1969 to 2023. A total of 6398 articles were published in 3983 different journals, most of them original articles (4040, 63.1%) and conference proceedings (1701, 26.6%). The United States is the most productive country with 1847 articles and 29% of the total literature, followed by China with 596 articles and 9.3% of the total literature. Chinese Academy of Sciences was found to publish the highest number of documents with 72 articles and to cover 1.1% of the total literature followed by United States Geological Survey with 42 articles and to cover 0.6% of the total literature. Most used six keywords were "Remote sensing", "Spatial analysis", "Mapping", "Groundwater", "AHP" and "Big data" (n = 255, 164, 130, 121, 98, and 97 times, respectively. The top two authors who contributed most were Goodchild, M.F. (22 articles), Ehlers, M. (14 articles). The top-cited publication was "Extracting topographic structure from digital elevation data for geographic information system analysis" with 1964 citations.

1. Introduction

Emerging Information and Communication Technology (ICT) offers academics significant opportunities in many ways, from data collection and analysis, to finalization of results, to the publication of scientific papers to the academic community. In addition to all these advantages, these advantages help scientists improve the standard, quality and reduce the time it takes to complete a study. The incorporation of ICT into the publishing industry changed academia and scholarly communication in general (Mohamad et al., 2013). One of the information systems used extensively by academics in many different disciplines is the Geographic Information System (GIS). Looking at the development process, GIS first emerged in the 1960s, began to be used largely in the public sector, and then began to be used in many fields in the 1970s and 1980s. In general terms, GIS is a computer system that captures, stores, processes, analyzes and displays geo-based referenced data (Fahui, 2006; Önder et al., 2022). To date, GIS has been applied in many disciplines (e.g. environmental science, computer science, ecology, geography, library and information science) (Yalçın et al., 2022; Yıldız & Şişman, 2022). Many scientific studies have been conducted on the use of GIS in these disciplines. Every year, hundreds of thousands of scientific-based articles are published in journals at an international level. Scientific journals are considered as the most important communication tool in which the latest findings and developments related to the discipline they belong to are conveyed (Kantek et al., 2019). Articles published in these journals are more attractive to researchers because of the subject they contain, the introduction of the latest scientific research, their criticism, and their contributions to the evolution of knowledge (Erfanmanesh & Nojavan, 2016).

Today, the most important communication tool in which scientific information is produced and shared is peer-reviewed journals (Matcharashvili et al., 2014). Presenting the data obtained about the leading journals of each science field with objective scientific methods, comparing and evaluating the results, provides an understanding of the development and change stages of the discipline. For this reason, it is recommended to examine the performances and trends in the field of individuals, institutions and publications that ensure the transfer and dissemination of information produced in any field through journals. The most commonly used method for this purpose is bibliometric analysis (BA). The BA is a useful tool for providing quantitative analysis of scientific-based research productivity in any field based on the number of articles and citations in international peer-reviewed journals (Matcharashvili et al., 2014; Nascimento et al., 2019). Bibliometric analysis

***Corresponding Author**

(mert.kayalik@ikcu.edu.tr) ORCID ID 0000–0002–1666–2215
(osmansami.kirtiloglu@ikcu.edu.tr) ORCID ID 0000–0003–2307–1787
*(zeynelabidin.polat@ikcu.edu.tr) ORCID ID 0000–0002–4127–3705

Cite this article

Kayalık M, Kırtıloğlu O S & Abidin Z (2023). Evolution and future trends in global research on geographic information system (GIS): a bibliometric analysis. *Advanced GIS,* 3(1), 22-30.

studies are the method of mathematically examining scientific publications made in a specific field, using specific keywords, authors, countries, institutions, years of publication, number of citations, journals in which they are published, number of authors, language of publication and sources used in publications. It is a type of study that has been done widely in recent years. While it was used mostly in social sciences at the beginning, it has been used frequently in the fields such as health and engineering in recent years (Rosas et al., 2011; Küçük et al., 2021).

Despite the growing interest, there has been little scientific work that can guide society about the scientific activities being done at the global level in the field of GIS. Tian et al. (2008) analyzed publications in all subject categories of the Science Citation Index compiled by the institute for Scientific Information (ISI) between 1997 and 2006 to evaluate the global scientific production of GIS articles. Mohamad et al. (2013) aimed to help researchers better understand the publication status of GIS-based studies between 2002 and 2011 and improve the applicability of GIS in many fields by analyzing the studies conducted between 2002 and 2011 and indexed in the Web of Science database. Bielecka (2020) made a bibliometric analysis of studies on the use of GIS-based spatial analysis model in land use change. The Web of Science was chosen as the data source for the studies analyzed in this study. Garramone et al. (2021) conducted a bibliometric analysis of studies focusing on GIS BIM integration for the management of infrastructure assets. Shkundalov & Vilutienė (2021) conducted a bibliometric analysis of studies covering building ınformation modeling, geographic ınformation systems and web environment integration.

Although there are a limited number of studies in the literature, researching and examining the studies produced in the field of GIS is important in terms of seeing at what level the concept of GIS is perceived and where it will reach in the future. In this study, the scientific literature on GIS presented in the SCOPUS database was reviewed using the bibliometric analysis (BA) method. In this way, it is aimed to guide the scientists who want to work in this field by analyzing the publications in terms of the number of citations, publication type, publication status, publication date, publication year, author productivity, keywords used, country or institution in which they are published.

2. Method

2.1. Bibliometry

A bibliometric analysis is a very useful tool to obtain valuable information and knowledge about the evolution of scientific research studies in specific disciplines (Ye, 2014; Niu et al., 2016; Li et al., 2018), which helps researchers to recognize novel trends and interests within investigation frameworks (Abejón et al., 2017; Zyoud et al., 2017). The value of BA increases depending on the number of publications in literature because BA sometimes allow us to analyze lots of publications about a specific topic or research interest and reveal the most productive publications, countries, authors, collaborations between the institutions, and active journals. There are many studies in the literature that contain BA of many journals operating in different disciplines (Such as medicine, information science, finance, marketing, engineering).

Bibliometric studies that have increased in number and quality recently, analyzing scientific studies on a subject in some aspects, number, journal in which they are published, citation status, the author who has published the most in that field, which subjects are studied, which subjects should be studied, research and analysis method. When bibliometrics is examined as a concept, it means the examination of scientific articles, books, journals with mathematical and statistical techniques and the determination of relationships. It is known that the first bibliometric study was done by Cole & Eales in 1917. In our country, the first known bibliometric analysis study was conducted by Ozınonu in 1970 (Al, 2008). Bibliometric studies mostly seek answers to the following questions:

- In which years were the studies carried out?
- Which database was used?
- What are the keywords used?
- What is the number of citations to the studies?
- Which universities or institutions produce the most publications?
- Who are the authors who produce the most publications?
- In which countries have the most publications been made?

2.2. Data Sources and Methodology

2.2.1. Data Sources

The bibliometric data source used in this article was obtained from the online platform of Scopus database. Scopus is a comprehensive database of abstracts and citations that provides access to rich data and academic literature in different disciplines. Launched in November 2004 (Zhang et al., 2017), Scopus is a source-independent database of abstracts and citations compiled by independent and unbiased subject matter experts (Scopus, 2023).

In general, the Scopus database is considered one of the most popular databases covering scientific journals, books, conference proceedings. (Singh et al., 2021). Scopus was searched online using the keyword “Geographical Information System (GIS)” to find a complete bibliography of all relevant articles directly related to GIS. The search made in the database on January 2023 covers the period from 1969 to 2023. Since the oldest study scanned in the database belongs to 1969, the search period covers the years 1969 to 2023.

2.2.2. Methodology

The term "bibliometrics" was first defined by Pritchard (1969) as "the application of mathematical and statistical methods to scientifically based communication tools (eg books, articles)". Bibliometrics are closely related new scientific fields that measure and analyze scientific publications in a particular field (Pritchard,

1969; Hood & Wilson, 2001; Ho, 2007; Abejón et al., 2017; Senel & Demiri, 2018). Bibliometric methods come to the fore to predict the scientific output or research trends of authors, journals, institutions and countries, and even to determine and measure international cooperation (Niu et al., 2016). This study includes the use of quantitative BA methods and social network analysis (SNA). SNA has been widely used to visualize and analyze relationships between various nodes in bibliometric studies, such as keyword collaborative use, academic collaborations between authors, institutions, and countries (Li et al. 2018). In order to evaluate and determine the trends in the scientific field related to the GIS subject, the subject indexes in which the database is classified, the most frequently used author keywords in each subject category, the articles with the highest number of citations were taken into consideration. In this context, 6398 articles published in the period from 1969 to January 2023 and indexed in the scopus database were analyzed. This study also uses the VOSviewer software to graphically map the co-occurrences of authors, key words and countries in the articles by published by Scopus.

3. Results

3.1.1. General trends

A set of 6398 published papers were obtained from Scopus database. The distribution of the number of publications by years is given in Figure 1. According to these data, there has been a significant increase in the number of publications, especially since the 90s. The reason for this increase is that the problems encountered during data collection, analysis and publication are largely solved with the developing technology and access to resources is facilitated.

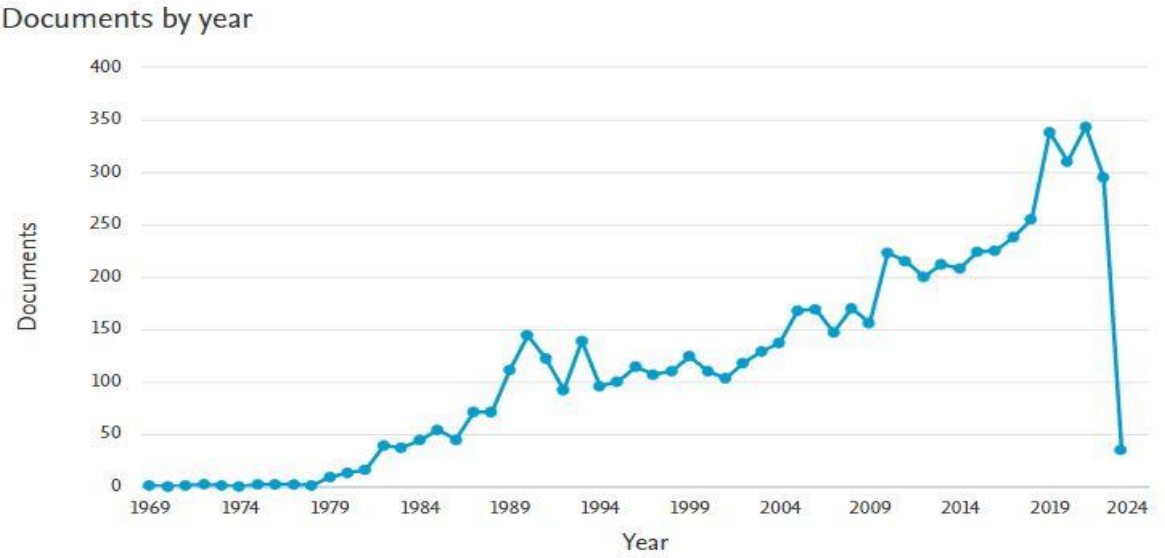


Figure 1. Evolution of published papers between 1969 and 2023

The distribution of document types of 6398 publications indexed by Scopus was analyzed. According to the results of this analysis, the published studies were prepared in 11 different document types (Table 1). The article (n: 4040) was the most frequently used document type comprising 63.1% of the total production, followed by Conference paper (1701, 26.6%). Book chapters (231, 3.6%), reviews (201, 3.1%), conference review 71, 1.1%), editorial (46, 0.7%), erratum (30, 0.5%), letter (21, 0.3%), book (20, 0.3%), and others (22, 0.3%) showed lesser significance than articles and conference papers.

Table 1. Document types of the publications

Document type	Number of publications	Percentage (%)
Article	4040	63.1
Conference paper	1701	26.6
Book chapter	231	3.6
Review	201	3.1
Conference review	71	1.1
Editorial	46	0.7
Erratum	30	0.5
Letter	21	0.3
Book	20	0.3
Note	15	0.2
Other	22	0.3

3.1.2. Distribution of journals

4040 of 6398 publications were published as articles. These articles have been published in 3983 different journals. Table 2 shows the 10 journals with more than 20 published articles with the total number articles, impact factor, Scopus subject categories.

There was a high contribution related to GIS research from these journals. According to Table 2, "Transportation Research Record" published the most articles on GIS (150; 3.7%), followed by "Photogrammetric Engineering Remote Sensing" (33; 0.8%), "Geocarto International" (31; 0.7%), and "Computers Environment and Urban Systems" (31; 0.7%).

Table 2. Most productive journals in GIS research

Journal	Number of article	Percentage of the articles in total number (%)	Impact factor
Transportation Research Record	150	3.7	2.019
Photogrammetric Engineering Remote Sensing	33	0.8	-
Computers Environment And Urban Systems	31	0.72	6.454
Geocarto International	31	0.72	3.450
Sustainability Switzerland	29	0.71	-
Environmental Monitoring And Assessment	27	0.66	3.307
Arabian Journal Of Geosciences	26	0.64	1.827 (2020)
Environmental Earth Sciences	21	0.51	3.119 (2021)
Environmental Management	21	0.51	3.644 (2021)
ISPRS International Journal Of Geo Information	21	0.51	3.099 (2021)

3.1.3. Country productivity and global network of collaboration

146 different countries around the world contributed to 6398 publications. Among these countries, the countries that contributed the most and the number of publications are given in Table 3. It was obvious that the most productive countries are United States (1847 articles, 29%), China (596 articles, 9.3%), Indonesia (291 articles, 4.5%), India (240 articles, 3.7%), and Canada (238 articles, 3.7%) respectively.

Table 3. The 10 most productive countries in GIS research during 1969–2023

Rank	Name of country	Number and percentage of countries' articles
1	United States	1847 (29%)
2	China	596 (9.3%)
3	Indonesia	291 (4.5%)
4	India	240 (3.7%)
5	Canada	238 (3.7%)
6	United Kingdom	222 (3.5%)
7	Iran	179 (2.8%)
8	Australia	156 (2.4%)
9	Brazil	155 (2.4%)
10	Turkey	154 (2.4%)
11	Other country	3246(50.7%)

The distribution and number of contributing countries shows that the development of GIS has been contributed from all over the world. The relations of the most productive countries with each other are given in Figure 2. The size of each bubble in Figure 2 represents each country's contribution to publication. The link between the two balloons shows the relationship between the countries in the publications. Data on publications are graphed using VOSviewer. Figure 2 shows that interoperability between these countries is quite strong, intense and sustainable.

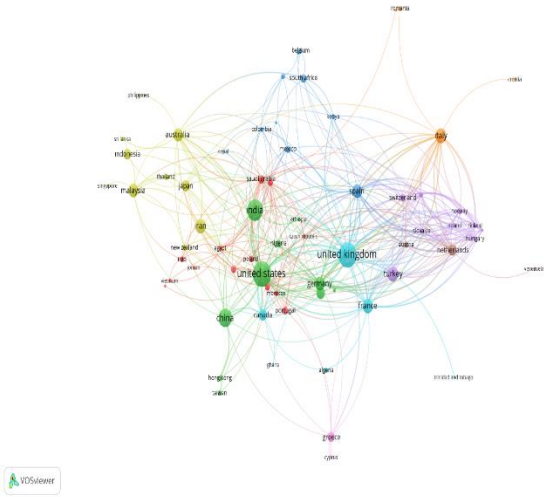


Figure 2. Co-occurrence network of countries/territories (more than 3 publications) in GIS research during 1969–2023

3.1.4. Publication distribution of institutions

162 different institutions contributed to 6398 publications. The 10 most productive institutions contributing 25 or more publications are listed in Table 4. The most productive institutions are Chinese Academy of Sciences (72 articles; 1.1%), United States Geological Survey (42 articles; 0.6%), University of California, Santa Barbara (41 papers; 0.6%), Louisiana State University (36 articles, 0.5%), and University of Minnesota Twin Cities (34 articles, 0.5%) respectively. According to the data in Table 4, the majority of the institutions in the top ten are institutions in the United States and China.

Table 4. The most productive institutions

Rank	Name of institution	Country	Number and percentage of institution's articles
1	Chinese Academy of Sciences	China	72 (1.1%)
2	United States Geological Survey	United States	42 (0.6%)
3	University of California, Santa Barbara	United States	41 (0.6%)
4	Louisiana State University	United States	36 (0.5%)
5	University of Minnesota Twin Cities	United States	34 (0.5%)
6	Pennsylvania State University	United States	31 (0.4%)
7	Texas A&M University	United States	29 (0.4%)
8	Wuhan University	China	29 (0.4%)
9	Ministry of Education China	China	28 0.4%)
10	University at Buffalo, The State University of New York	United States	27(0.4%)
11	Other institution (152)	Other countries	1935(30%)

3.1.5. Author productivity and global network of collaboration

According to the results of the analysis, 6387 authors contributed to at least 1 article on GIS. 731 of these authors contributed to 3 or more articles. The 10 most prolific authors who contributed 8 or more articles are listed in Table 5. This is an indication that top productivity writers have made major contributions to GIS research. The most productive authors are Goodchild, M.F. (22 articles, 1.01%), Ehlers, M. (15 articles, 0.83%), Malone, J.B (14 articles, 0.82%), Marble, D.F (14 articles, 0.82%) and Dangermond, J. (12 articles, 0.66%), respectively.

Table 5. The most productive authors working on GIS research

Rank	Name of author	Number and percentage of author's articles
1	Goodchild	22 (1.01%)
2	Ehlers	13 (0.83%)
3	Malone	14 (0.82%)
4	Marble	14 (0.81%)
5	Dangermond	12 (0.66%)
6	Gahegan	10 (0.62%)
7	Qin	10 (0.62%)
8	Estes	9 (0.58%)
9	Robinson	9 (0.54%)
10	Clarke	8 (0.54%)
11	Other authors (3 or more articles)	721(11.2%)

The frequent use of co-authoring networks in determining collaboration trends and highlighting scientists and organizations that shape science shows that they are a very important tool (Fonseca et al. 2016). Collaborations among 731 authors, who published more than three articles, were shown in Figure 3. The size of each bubble in Figure 3 indicates the density of the author's publications on GIS research. The bubbles are colored based on the total publication of the author in this research area. A link between two bubbles indicates a co-authorship relationship for tree or more publications on GIS research. The graphs showing the relationships of the co-authors were drawn using VOSviewer.

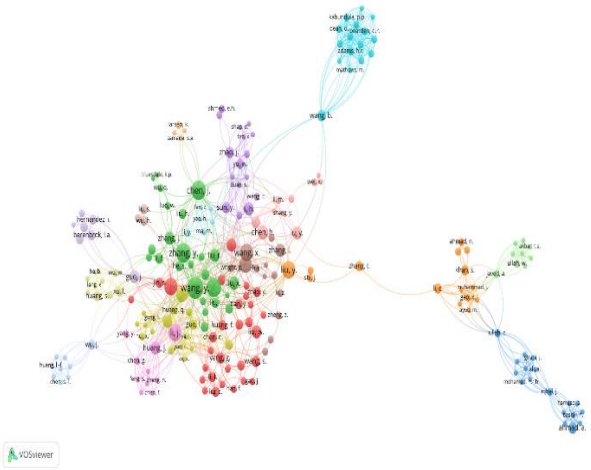


Figure 3. Co-authorship network of authors with three or more publications on research

3.1.6. Subject categories

GIS-themed studies published in the period 1969-2023 were classified in 27 subject categories determined by Scopus. These categories are closely related so that a single article can be assigned to more than one subject category. The existence of so many subject categories is an indication that GIS is used in all areas. Topic categories that overlap most with the articles are listed in Table 6. The five most common categories were Environmental Science, Earth and Planetary Sciences, Engineering, Computer Science, Social Sciences.

Table 6. Top 10 subject categories

Rank	Subject categories	Number and percentage of articles in Subject categories
1	Environmental Science	1911 (29.8%)
2	Earth and Planetary Sciences	1768 (27.6%)
3	Engineering	1555 (24.3%)
4	Computer Science	1304 (20.3%)
5	Social Sciences	1232 (19.2%)
6	Medicine	658 (10.2%)
7	Agricultural and Biological Sciences	637 (9.9%)
8	Mathematics	331 (5.1%)
9	Energy	279 (4.3%)
10	Physics and Astronomy	235 (3.6%)
11	Other categories (17)	1272(19.8%)

3.1.7. Key word analysis and hot issues

Searching for frequently mentioned terms (Goyal 2017) or author keywords (Abejón et al. 2017) in article titles and abstracts can gather relevant information to identify research trends, hot topics, methods and policies in a particular field. Keywords provide very important information about the content of the article (Singh et al., 2019). A common network analysis between keywords can be used to track research topics and emerging trends (Kevork & Vrechopoulos, 2009). 5008 different keywords were used 7232 times in 6398 articles. Social network analysis with 5008 keywords is given in Figure 4.

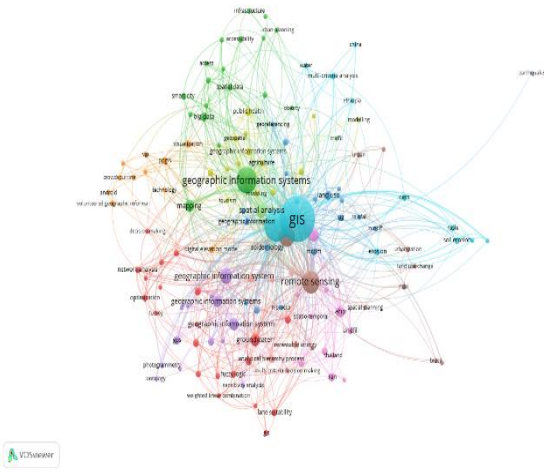


Figure 4. Social network analysis with 5008 keywords

The 15 most used keywords (more than 60) in the articles are listed in the Table 7. Most used six keywords were "Remote sensing", "Spatial analysis", ''Mapping'', ''Groundwater'', ''AHP'' and ''Big data'' (n = 255, 164, 130, 121, 98 and 97 times, respectively.

Table 7. Most used keywords

Rank	Keywords	Frequency of use of the keyword in the article	Number of keywords used together
1	Remote Sensing	255	118
2	Spatial analysis	164	76
3	Mapping	130	72
4	Groundwater	121	65
5	AHP	98	23
6	Big data	97	70
7	Site Selection	95	106
8	Agriculture	88	100
9	Land use	87	105
10	Flood	79	34

3.1.8. Highly cited papers

The number of citations a publication receives is an important indicator for measuring its impact in the research field. 10 articles receiving more than 340 citations are listed in Table 8. The most cited paper was published in 1988 by Jenson, S.K and et al. (n=1964). The title of the article is "Extracting topographic structure from digital elevation data for geographic information system analysis". The second most cited article (n=786), was published in 2006 by Sieber R. This article focuses on public participation in GIS. The third most cited article (n=592) was in 1995 by Pickles, J. This article focuses on the social effects of geographic information systems.

Table 8. The top 10 highly cited publications during 1969-2023

Rank	Title	Author(s)	Year	Source	Number of Citations
1	Extracting topographic structure from digital elevation data for geographic information system analysis	Jenson & Domingue	1988	Photogrammetric Engineering and Remote Sensing, 54(11), pp. 1593–1600	1964
2	Public participation geographic information systems: A literature review and framework	Sieber	2006	Annals of the Association of American Geographers, 96(3), pp. 491–507	786
3	Ground truth: the social implications of geographic information systems	Pickles	1995	Ground truth: the social implications of geographic information systems,	592
4	It's About Time: A Conceptual Framework for the Representation of Temporal Dynamics in Geographic Information Systems	Peuque	1994	Annals of the Association of American Geographers, 84(3), pp. 441–461	449
5	Walkability of local communities: Using geographic information systems to objectively assess relevant environmental attributes	Leslie et al.	2007	Health and Place, 13(1), pp. 111–122	447

Table 8. (Continued)

Rank	Title	Author(s)	Year	Source	Number of Citations
6	Time in geographic information systems	Langran	1992	Time in geographic information systems,	424
7	Estimating lonq-term average particulate air pollution concentrations: Application of traffic indicators and geographic information systems	Brauer et al.	2003	Epidemiology, 14(2), pp. 228–239	415
8	Associations of the local food environment with diet quality - A comparison of assessments based on surveys and geographic information systems	Moore et al. Jacobs	2008	American Journal of Epidemiology, 167(8), pp. 917–924	413
9	Geographic information systems: a management perspective	Aronoff	1989	Geographic information systems: a management perspective,	378
10	Development of a framework for fire risk assessment using remote sensing and geographic information system technologies	Chuvieco et al.	2010	Ecological Modelling, 221(1), pp. 46–58	348

4. Discussion

Since the first article published in 1969, thousands of scientific studies on GIS have been published until 2023. These scientific studies show that GIS plays a very important role in collecting, analyzing, visualizing and sharing scientific information in many fields such as Engineering, earth and space science, environment, health, computer science, energy, agriculture and biology, social sciences. In this study, all GIS articles indexed in the Scopus database from 1969 to 2023 were analyzed using BA methods and knowledge mapping tools, and the development process and domain of GIS were revealed. Most used keywords with GIS are "Remote sensing", "Spatial analysis", "Mapping", ''Groundwater'', ''AHP'', ''Big data'', ''Site selection'', ''Agriculture'', ''Land use'' and ''Flood''. These keywords, which were popular in different periods of GIS, revealed that GIS formed the basis of many scientific fields between 1969-2023 and played an important role in data architecture. Both the significant majority in the number of authors and the distribution of countries show that GIS is followed by many scientists in many countries around the world. Especially the authors of highly cited studies have an important role in the recognition of GIS. According to the results of the analysis, many public institutions and universities have played a key role in the development of GIS. The majority of these institutions and universities operate in the USA and China. This is an indication that GIS contributes to the development of countries with large economies. Also, the results from this analysis can be used for the future research direction of GIS. For example, the frequency of publications on GIS-based remote sensing systems, measurement techniques, spatial data modeling, AHP, suitability analysis, and land uses indicates that these topics will become popular in the future.

5. Conclusion

The purpose of this study was to trace the development of his 'GIS'. This study provides an overview of the articles indexed in the Scopus database and published from 1969 to 2023. The data used in this study were obtained using the Scopus online database. A total of 6398 publications of different types (e.g. articles, proceedings, reports) published since 1969 were examined. The results of the analysis show that the high increase in the number of articles and citations took place especially after the 90s. The 6398 publications contributed by 6387 authors from 146 different countries show how widespread the impact of GIS is. The need for geographic data is increasing day by day, and the importance of geographic information systems is increasing. The findings obtained as a result of this analysis show that GIS is used in many countries in an integrated manner with many fields. In addition, studies conducted regularly for many years show that GIS will continue to be an important topic in the future. Repeating a similar study in later periods may allow periodic comparison of the findings with the findings obtained from this study.

Author Contributions

The contributions of the authors of this article is equal.

Statement of Conflicts of Interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

Research and publication ethics were complied with in the study.

References

Abejón, R., Pérez-Acebo, H., & Garea, A. (2017). A bibliometric analysis of research on supported ionic liquid membranes during the 1995–2015 period: Study of the main applications and trending topics. *Membranes*, 7(4), 63. https://doi.org/10.3390/membranes7040063

Al, U. (2008). *Scientific publication policy of turkey: a bibliometric approach based on citation indexes.*

[Doctoral Thesis, Ankara University]. YÖK National Thesis Center.

Bielecka, E. (2020). GIS spatial analysis modeling for land use change. A Bibliometric Analysis of the Intellectual Base and Trends. *Geosciences,* 10(11), 421. https://doi.org/10.3390/geosciences10110421

Erfanmanesh, M., & Nojavan, F. (2016). Qualitative and quantitative status and international visibility of Iranian journals indexed in Journal Citation Reports. Iranian *Journal of Information Processing & Management*, 32 (1), 51-73.

Fahui, W. (2006). *Quantitative methods in applications in GIS.* CRC Press Taylor & Francis Group.

Fonseca, B. P. F., Sampaio, R. B., Fonseca, M. V. A., & Zicker, F. (2016). Co-authorship network analysis in health research: Method and potential use. *Health Research Policy and Systems*, 14(1), 34. https://doi.org/10.1186/s12961-016-0104-5

Garramone, M., Moretti, N., Scaioni, M., Ellul, C., Cecconi, R., & Dejaco, M. C. (2020). BIM and GIS integration for infrastructure asset management: a bibliometric analysis. *ISPRS annals of photogrammetry, Rem. Sens. Spatial Information Sciences.,* 6(4W1), 77-84. https://doi.org/10.5194/isprs-annals-VI-4-W1-2020-77-2020

Goyal, N. (2017). A review of policy sciences: bibliometric analysis of authors, references, and topics during 1970–2017. *Policy Sciences*, 50(4), 527–537. https://doi.org/10.1007/s11077-017-9300-6

Ho, Y. S. (2007). Bibliometric analysis of adsorption technology in environmental science. *Journal of Environmental Protection Science*, 1(1), 1-11.

Hood, W. W., & Wilson, C. S. (2001). The literature of bibliometrics, scientometrics, and informetrics. *Scientometrics*, 52(2), 291–314. https://doi.org/10.1023/a:1017919924342

Kantek, F., Kurnaz, H., & Yeşilbaş, H. (2019). Bibliometric analysis of the journal of health and nursing management. *Journal of Health and Nursing Management*, 3(6) 228-237. https://doi.org/10.5222/SHYD.2019.32559

Kevork, E. K., & Vrechopoulos, A. P. (2009). CRM literature: Conceptual and functional insights by keyword analysis. *Marketing Intelligence & Planning*, 27(1), 48–85. https://doi.org/10.1108/02634500910928362

Küçük, U., Alkan, S., & Uyar, C. (2021). Bibliometric analysis on infective endocarditis. *Iberoamerıcan Journal of Medıcıne,* 350-355. http://dx.doi.org/10.53986/ibjm.2021.0055

Li, N., Han, R., & Lua, X. (2018). Bibliometric analysis of research trends on solid waste reuse and recycling during 1992–2016. *Resources, Conservation and Recycling*, 130, 109-117. https://doi.org/10.1016/j.resconrec.2017.11.008

Matcharashvili, T., Tsveraidze, Z., Sborshchikovi, A., & Matcharashvili, T. (2014). The importance of bibliometric indicators for the analysis of research performance in Georgia. *Journal of the Humanities and Social Sciences*, 18(4), 345–356.

Mohamad, A. N., Masrek, M. N., & Rasam, A. R. B. A. (2013). A bibliometric analysis on scientific production of Geographical Information System (GIS) in Web of Science. *2013 International Conference of Information and Communication Technology (ICoICT),* Bandung, Indonesia, 264-268.

Nascimento, A. S., Oliveira, F. S., & Bianconi, M. L. (2019). Bibliometric analysis of the brazilian periodical journal of biochemistry education. *Biochemistry and Molecular Biology Education*, (47)3, 249–256. https://doi.org/10.1002/bmb.21220

Niu, J., Tang, W., Xu, F., Zhou, X., & Song, Y. (2016). Global research on artificial intelligence from 1990–2014: Spatially-explicit bibliometric analysis. ISPRS *International Journal of Geo-Information*, 5(5), 66. https://doi.org/10.3390/ijgi5050066

Ozinonu, A. K. (1970). Growth in *Turkish positive basic sciences, 1933-1966.* Middle East Technical University.

Önder, M., Güntel, A., & Kaya, Ö. Y. (2022). A geographical information systems (GIS) Perspective on European green deal and sustainability. *Advanced GIS Journal*, 2(1), 33–38.

Pritchard, A. (1969). Statistical bibliography or bibliometrics? *Journal of Documentation*, 25(4), 348–349.

Rosas, S. R, Kagan, J. M., Schouten, J. T., Slack, P. A., & Trochim, W. M. K. (2011). Evaluating research and impact: a bibliometric analysis of research by the NIH/NIAID HIV/AIDS clinical trials networks. *PLoS One*, 6(3). https://doi.org/10.1371/journal.pone.0017428

Scopus. (2023). *Scopus Content Coverage Guide*. Scopus. Retrieved March 14, 2023, from https://www.elsevier.com/__data/assets/pdf_file/0007/69451/Scopus_ContentCoverage_Guide_WEB.pdf

Shkundalov, D., & Vilutienė, T. (2021). Bibliometric analysis of building information modeling, geographic information systems and web environment integration. *Automation in Construction,* 128. https://doi.org/10.1016/j.autcon.2021.103757

Singh, V. K., Singh, P., Karmakar, M., Leta, J., & Mayr, P. (2021). The journal coverage of web of science, scopus and dimensions: A comparative analysis. *Scientometrics,* 126, 5113–5142. https://doi.org/10.1007/s11192-021-03948-5

Senel, E., & Demiri, E. (2018). Bibliometric and scientometric analysis of the articles published in the journal of religion and health between 1975 and 2016. *Journal of Religion and Health*, 57(4), 1473-1482. https://doi.org/10.1007/s10943-017-0539-1

Tian, Y., Wen, C., & Hong, S. (2008). Global scientific production on GIS research by bibliometric analysis from 1997 to 2006. *Journal of Informetrics*, 2(1), 65–74. https://doi.org/10.1016/j.joi.2007.10.001

Yalçın, C., Öztürk, S., & Kumral, M. (2022). Heat maps of u-th enrichments in open source coded geographical information systems (GIS); Arıklı (Çanakkale, Turkey) District. *Advanced GIS Journal*, 2(2), 46-51.

Ye, Z., Zhang, B., Liu, Y., Zhang, J., Wang, Z., & Bi, H. (2013). A bibliometric investigation of research trends on sulfate removal. *Desalination and Water Treat*, 52

(31–33), 6040–6049. https://doi.org/10.1080/19443994.2013.812991

Yıldız, N., & Şişman, A. (2022). Investigation of flood risk areas in Ünye district with Best-Worst method using geographic information systems. *Advanced Land Management*, 2(1), 21–28.

Zhang, H., Huang, M., Qing, X., Li, G., & Tian, C. (2017). Bibliometric analysis on global remote sensing research during 2010–2015. *ISPRS International Journal of Geo-Information*, 6(11), 332. https://doi.org/10.3390/ijgi6110332

Zyoud, S. H. H., Fuchs-Hanusch, D., Zyoud, S. H., Al-Rawajfeh, A. E., & Shaheen, H. Q. (2017). A bibliometric-based evaluation on environmental research in the Arab world. *International Journal of Environmental Science and Technology*, 689–706. https://doi.org/10.1007/s13762-016-1180-3