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# GIS IN RESEARCH PAPERS FROM 2013–2023: BIBLIOMETRIX AS A TOOL FOR BIBLIOMETRIC ANALYSIS IN R

**Abstract:** Based on the SCOPUS database, the study shows the results of a bibliometric analysis of scientific publications related to Geographic Information Systems (GIS) from 2013–2023. The study covers 8528 papers and is intended to understand research trends and the geographic diversity of publications. This paper uses the bibliometrix tool, an R language package for bibliometric analysis. The results show that the most significant number of publications come from India and China, which also have high citation rates. Keyword analysis reveals that there has been increased interest in remote sensing, land use, urban planning, urbanization, environmental monitoring, risk assessment, and diagnostics of water quality and flood-prone areas in recent years. The survey provides valuable information on the direction of research related to Geographic Information Systems and points to the need for greater integration and cooperation in international research.

**Keywords:** GIS, Geographic Information Systems, bibliometrix, R language package

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## Introduction with analysis of the state of the problems

One of the interesting trends of recent years is the rapid growth of research involving the synthesis of previously published scientific research. Evaluating the number of scientific publications is growing quickly, and observing all papers in a given area for individual researchers is impossible. Therefore, various methods of scientific study synthesis are beginning to play a key role in analyzing research trends. One of the classic methods was publications in the form of a broad literature review. This method's benefit was its ability to analyze particular papers, research techniques, or scientific theses in great depth. The comparatively small quantity of scientific papers examined constituted a drawback, though. Increased accessibility to databases such as SCOPUS or Web of Science has provided access to detailed data on scientific articles, and the number of such data ranges from several thousand to several hundred thousand records. As a result, an area of research (called bibliometrics) has emerged, which, despite the overwhelming amount of information, makes it possible to show an organized knowledge of a research topic and identify trends, gaps, or research frontiers. The main objective of the present study is therefore to use a bibliometric analysis of the scientific articles contained in the SCOPUS database that relate to Geographical Information Systems. Such a study will help to understand the directions and trends in this scientific discipline.

Bibliometric analysis is a comprehensive analytical method that provides an overall overview of various academic literature and enables us to comprehend the features and development of scientific production in the research subject (Basile et al., 2022; Çelik et al., 2024; Ridwana et al., 2025). Bibliometric analysis through the study of publication rates, number of citations, keywords, and affiliation of scholars makes it possible to identify key research trends, recent developments, and areas of interest and to observe the evolution of research and the decline of particular research methods or trends. Bibliometric methods are based on quantitative analysis of the scientific literature, which shows the overall research landscape in a given scientific area. There are several vital questions for bibliometric analysis (Passas, 2024):

- define research objectives,
- literature search and data collection,
- data cleaning and preprocessing,
- selection of bibliometric techniques,
- data analysis,
- visualisation
- interpretation and reporting.

Bibliometric analysis allows researchers to identify the most cited papers, with simultaneous indication of the author's country and affiliation, which helps regional identification. As a result, the dominant universities or countries in the research field can be identified. It makes it possible to select potential collaborators or research internship sites accordingly. Analysis of publication counts or citation counts allows researchers to analyze the upward or downward trajectory of research. Bibliometric analysis can also identify the dominant scientific journals in a scientific field or research methodology,

enabling the selection of publication venues. Researchers can detect changes in research trends, methods, and techniques by analyzing keywords, abstracts, and full-text content. Bibliometric analysis has been used in several scientific research areas, including:

- housing, property, and valuation (Chen et al., 2022; Lazar & Chithra, 2021),
- energy (Chen et al., 2016; Demiroz & Haase, 2019),
- healthy city and public space ergonomics (Çelik et al., 2024),
- social enterprise (Dionisio, 2019; Eri et al., 2023; Granados et al., 2011),
- quality of life (Aria et al., 2020),
- urologic cancer (Lan et al., 2024),
- business and management (Donthu et al., 2020; Sánchez-Pérez et al., 2025),
- autonomous vehicles (Gandia et al., 2019),
- finance (Baker et al., 2020; Khan et al., 2021).

Thus, bibliometric analysis is a universal tool for analyzing different areas of knowledge. In the current article, bibliometric analysis will help to understand the scientific landscape in geographic information systems (GIS).

The Geographic Information System, also known as GIS, is an operating system application that integrates spatial data with attribute information to analyze and visualize geographic relationships (Awange & Kyalo Kiema, 2013; Chang, 2019). Geographic Information System is an integrated information system that provides timely and quality spatial information for specific geographical applications, integrating knowledge from different disciplines and functions of various information technologies (Tang, 2005). The Geographic Information System tools can process and analyze different types of spatial data, including raster (image) data, graphics data, and tabular data, and provide a variety of functions for spatial analysis and visualization (McLeod et al., 1985). It can represent spatial relationships and real-world processes using both vector (points, lines, polygons) and raster data structures (Schweikart et al., 2008). Analyzing such a large dataset becomes easier with GIS tools (ArcGIS, QGis, or spatial analysis in R). It allows for quick and advanced study of the current state and prediction of future trends through a wide range of visualization. There are several examples of GIS application (Bieda & Maniak, 2024; Boers & Cottrell, 2007; Cellmer, 2023; Gao et al., 2017; Gnat, 2022; Krivoruchko, 2012; Ogryzek et al., 2022; Yu, 2007). After a general introduction to the essence of geographic information systems (GIS), the essential tools for implementing bibliometric research will be indicated.

Bibliometrix, VOSviewer, and SciMAT are some of the most influential and comprehensive tools for bibliometric and scientometric analysis, with each having its strengths in terms of techniques, visualization, and preprocessing capabilities (Moral-Muñoz et al., 2020). This study will use the potential of the software bibliometrix (Aria & Cuccurullo, 2017), which is an R package. R is open-source software, which means it is free software, but at the same time, it is without any guarantees. It is a programming language (code is used to execute tasks), a graphical environment, and a computing environment. Its great advantage is the freeware license (GNU GPL 2.0), the almost unlimited number of so-called libraries, and its unrivaled computational and graphical features, especially in chart editing. Note, however, that the libraries may be incompatible,

and the code notation is not easily understood. For more on this subject, see the broad literature (Basile et al., 2022; Hackenberger, 2020; Soetaert et al., 2010).

Bibliometrix R-package (http://www.bibliometrix.org) is a tool developed in the statistical and graphical language R, making it highly modifiable because it is object-oriented and is a functional programming language (Aria & Cuccurullo, 2017). Since it is an open-source software, getting help from the user community, which consists mainly of prominent statisticians, is easy. Therefore, bibliometrix is flexible and can be quickly updated and integrated with other statistical R packages. The process of bibliometric analysis in bibliometrix in R has been shown in Figure 1.

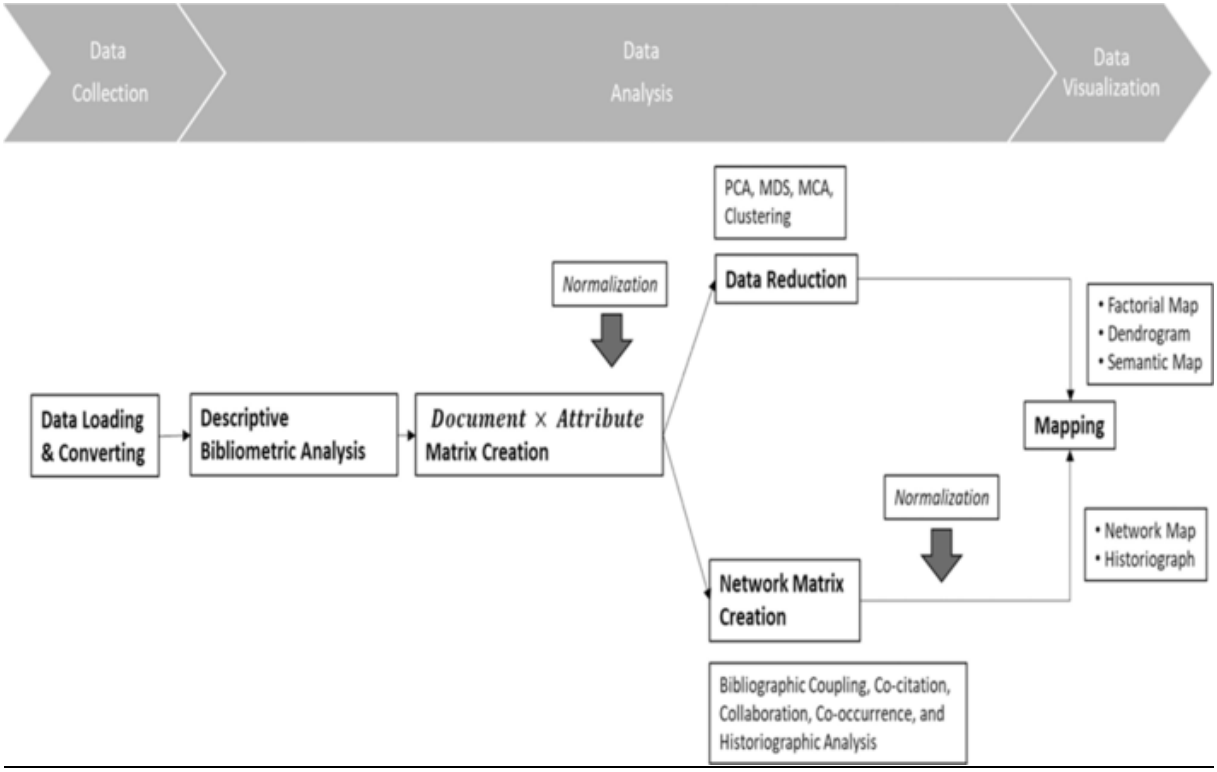


Fig. 1. Bibliometrix learning diagnostic processes
Source: (Aria & Cuccurullo, 2017)

## Materials and data analysis

The research's essence was to analyze the scientific community's interest (publication of scientific papers) in Geographic Information Systems. The study was conducted in the SCOPUS database (http://www.scopus.com, 15.09.2024) for 2013–2023. The result is the acquisition (in the form of a BibTeX file) of 8628 individual data on published scientific papers. The last decade was chosen for the study without considering the incomplete 2024. A detailed summary of the rules for searching the database, the selected keywords, and their abundance is presented in Table 1.

Table 1. Scopus database search rules 2013–2023

| Search Rule | Keywords | Number |
|---|---|---|
| Only Articles<br>Only Journals<br>Only English<br>Only in the article title | GIS | 5,040 |
| | Geographic Information Systems | 2,641 |
| | Geographic Information System | 947 |

Source: own study

Table 1 shows the fundamental rules according to which the SCOPUS database is searched in the context of three keywords: ”GIS", ”Geographic Information Systems," and ”Geographic Information System." The most common abbreviation term “GIS” (5,040) was in the titles of scientific papers, while equal versions of the full name were used in 3,588 articles. This indicates the recognizability and universality of the abbreviation GIS in the context of science. Table 2 presents a summary of the basic information that was obtained from the compilation of 8628 scientific papers.

Table 2. Main information about data from Scopus (2013-2023)

| Description | Result |
|---|---|
| Documents | 8528 |
| Annual Growth Rate % | 6.26 |
| Document Average Age | 5,34 |
| Average citations per doc | 23,62 |
| Authors | 22878 |
| Single authored docs | 665 |
| Co-Authors per Doc | 3.88 |
| International co-authorships | 24.92 |

Source: own study

Based on Table 2, it can be seen that almost 23,000 authors (2023–2023 SCOPUS) have dealt with the studied GIS-related topics, with an average of 3.88 co-authors per scientific article. An essential part of the research is that 24.92% of the publications were written with co-authors from other countries. On the other hand, the average number of citations is more than 23 per article, which shows the growing interest in this topic. Figure 2 shows the number of articles published per year and the number of citations per year from 2023–2023.

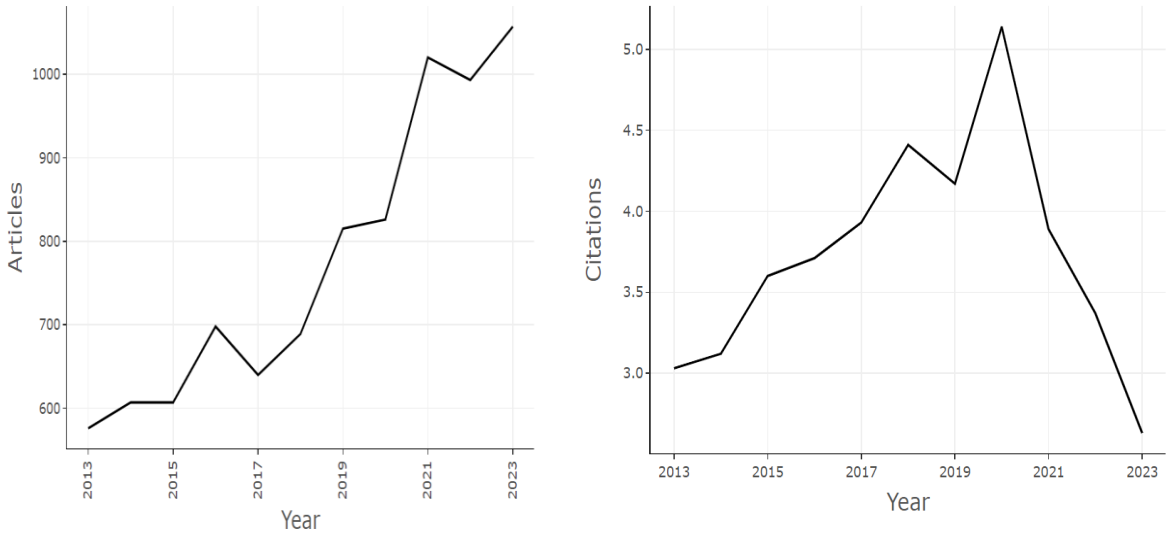


Fig. 2. Papers annual publication and citations per year
Source: own study

Figure 1 shows that between 2013 and 2023, there was a significant increase in the number of articles with the keyword "GIS," from 600 in 2013 to more than 1,000 articles in 2013. An analysis of the citations of these papers showed a maximum increase in 2020, followed by a sharp decline. This is a natural phenomenon due to the long time it takes to develop and publish scientific articles. It corresponds with the general interdisciplinary interest in modeling phenomena spatially using GIS tools. Table 3 and Table 4 show the number of publications and their citations divided by country.

Table 3. Number of publications by country

| Country | Frequency |
|---|---|
| India | 1388 |
| China | 1187 |
| United States | 1025 |
| Iran | 612 |
| Italy | 389 |
| Turkey | 373 |
| United Kingdom | 301 |
| Australia | 285 |
| Egypt | 285 |
| Spain | 284 |

Source: own study

Table 4. Papers citations by country

| Description | Most cited countries | Average Papers Citations |
|---|---|---|
| India | 26,856 | 23.5 |
| China | 25,180 | 24,2 |
| Iran | 13698 | 33.3 |
| USA | 10017 | 20.4 |
| Australia | 9175 | 37.0 |
| Turkey | 8379 | 27.5 |
| Malysia | 6973 | 47.1 |
| Italy | 5874 | 23.5 |
| Korea | 5191 | 36.8 |
| Egypt | 5106 | 24.0 |

Source: own study

As can be seen from the data in Table 3 and Table 4, individual European countries are not at the top of the most active in Geographic Information Systems publications. The highest in the hierarchy are publications from Italy (389) or the United Kingdom (301), then there are other countries from Spain (284), Germany (250), Greece (143), France (120), Poland (119), Portugal (96), Romania (96) and Sweden (90), among others. If we look at the total number of publications from European countries (1,879), however, it places them at No. 1 in the ranking. In terms of individual countries, most of the papers related to GIS are published in India and China, and the citations of publications from these countries are among the highest. Iran, the US, and Turkey are also very high in this ranking. Also surprising (from a European point of view) is the high position of Egypt. A simple analysis of the data in Table 1 and Table 2 shows the geographic diversity of researchers' interest in publishing on GIS, especially in Asia and North America.

## Results and discussion

The bibliometric study is based on 8528 scientific articles published in the SCOPUS database between 2013 and 2023. The data collected are detailed in the Materials and Data Analysis chapter. All graphs and calculations were performed in bibliometrix R-package (Aria & Cuccurullo, 2017). First, a so-called word cloud was prepared based on the keywords used by the authors in their publications. The graphical results of this analysis are shown in Figure 3.

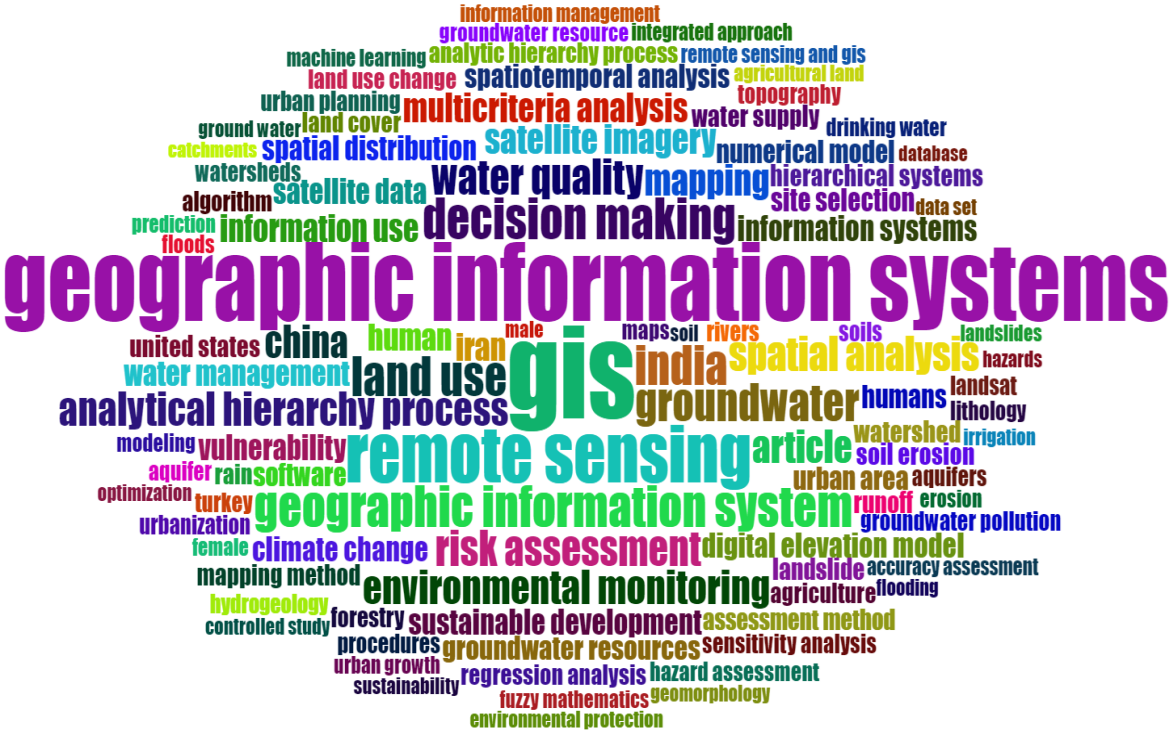


Fig. 3. Keywords in scientific papers related to GIS (2013–2023)
Source: own study

Graphical presentation of keywords (Figure 3) in scientific articles related to Geographic Information Systems can allow identification of current research areas and new areas of exploration. Excluding the primary keywords (GIS, Geographic Information Systems, Geographic Information System) from the analysis, it is possible to define the most critical research areas, such as:

- remote sensing,
- land use, urban planning, urbanization,
- spatial analysies,
- environmental monitoring,
- risk assessment,
- water quality, drinking water, or groundwater,
- decision making.

At the same time, one can observe the dominant research methods used in these articles, i.e., machine learning, fuzzy mathematics, regression analysis, or sensitivity analysis. To identify the ten most frequently used keywords, the so-called tree plot was used, where in Figure 4, the size of the geometric figure shows the frequency of the keywords in 8528 papers between 2013 and 2023. Interestingly, the keyword "India" was repeated as many as 1018 times, corresponding to the number of articles from this country. At the same time, issues related to "groundwater" and "water quality" appear in the top 10 keywords, which shows its global importance, although perhaps underestimated in Europe.


Fig. 4. Tree plot of the top 10 most frequently mentioned keywords in 2013–2023 in SCOPUS database
Source: own study

In the next stage of the work, a so-called Sankey graph has been created, which represents the flow of values from sources to destinations through bands that divide and merge at specific process hubs. Three hubs were selected for this bibliometric analysis: the author's country, the keyword, and the journal name in which the paper was published. The results are shown in Figure 5.

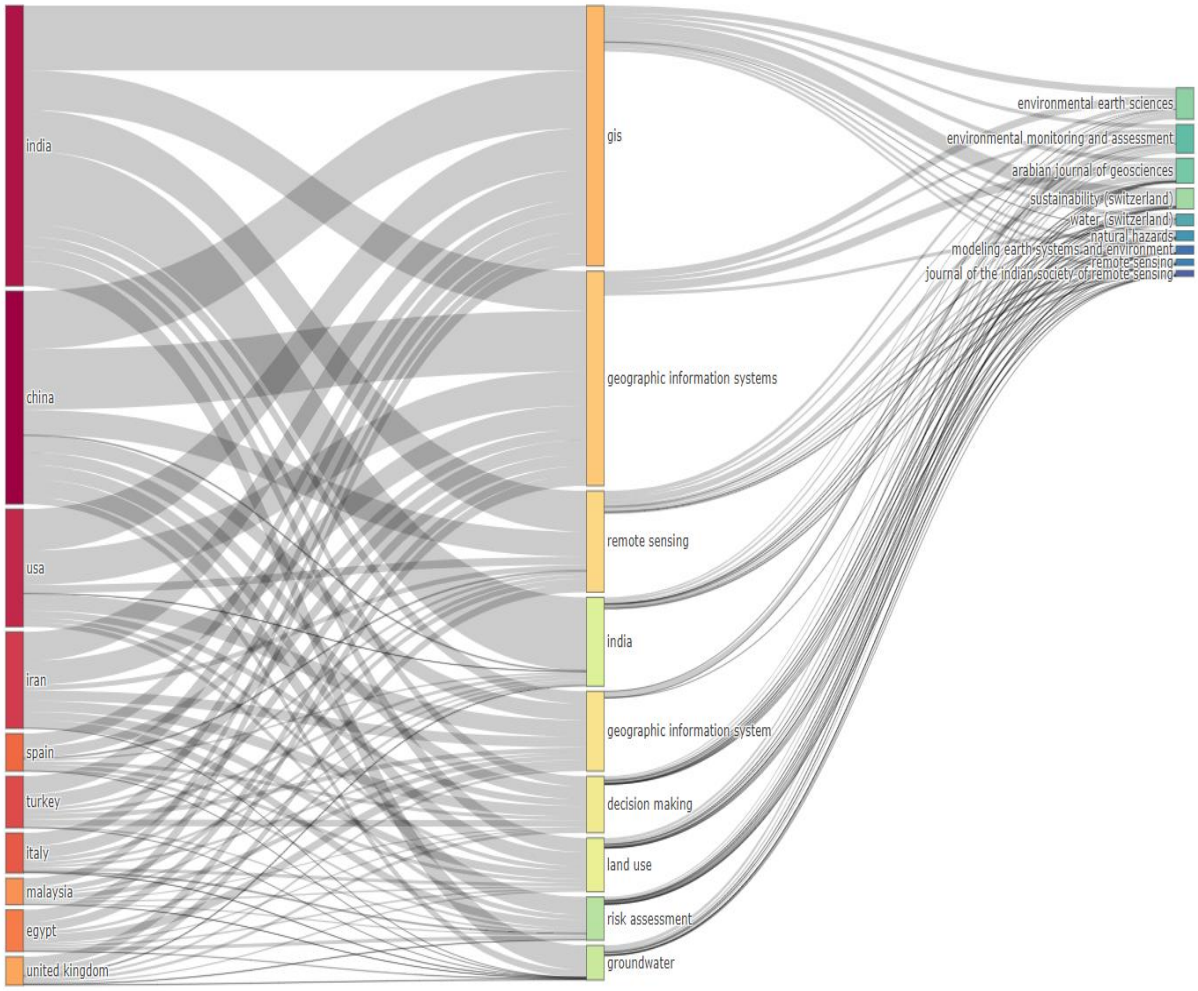


Fig. 5. Sankey flowchart for the selected three hubs: country, keyword, journal
Source: own study

The first vertical axis (left side) indicates the countries from which authors have published the most works regarding geographic information systems. Visible is the dominance of India, China, and the US. The central axis shows the most frequent keywords in scientific articles. Abstracting from the classic keywords for this study (GIS, Geographic Information System), one can see that in articles from India, the frequent use of the keywords "India" and "groundwater" indicates a significant water balance problem in the area. In contrast, publications from China focus heavily on the keywords: "decision making", "land use", "risk assessment", and, to a small extent, "groundwater". The last hub takes the name of the journal in which the scientific article was published. The most commonly published research results on GIS are in the journals: "Environmental Earth Sciences", "Sustainability", and "Journal of the Indian Society of Remote Sensing".

To show the changes over time (2013–2023) in the popularity of keywords, another analysis is presented in Figure 6. In this graph, the horizontal axis with a blue line marks the ranges of popularity of a keyword over time. As a result, research trends can be marked (by year), areas of declining research (minimum research volume) can be indicated, and changes in the research methodology used can be tracked. Figure 6 shows

that between 2013 and 2018, several scientific studies (GIS analysis) dealt with "habitat conservation", "health promotion", "stratigraphy", or "carbon monoxide", among others. In the following years, these topics did not represent a significant trend in publications related to geographic information systems. In the second half of the analyzed period (2013–2023), keywords related to decision-making methodologies, i.e., "multi-criteria decision-making" and "analytic hierarchy process", gained importance. At the same time, an increase in interest in various forms of mathematical modeling can be seen in this period, including "software", "databases", "models", "regression analysis", and "numerical models". From 2019 to 2023, there will be an increase in interest in environmental topics, e.g., "climate change". Additionally, "remote sensing" and "decision making" show significant importance and acceptance in the review process.

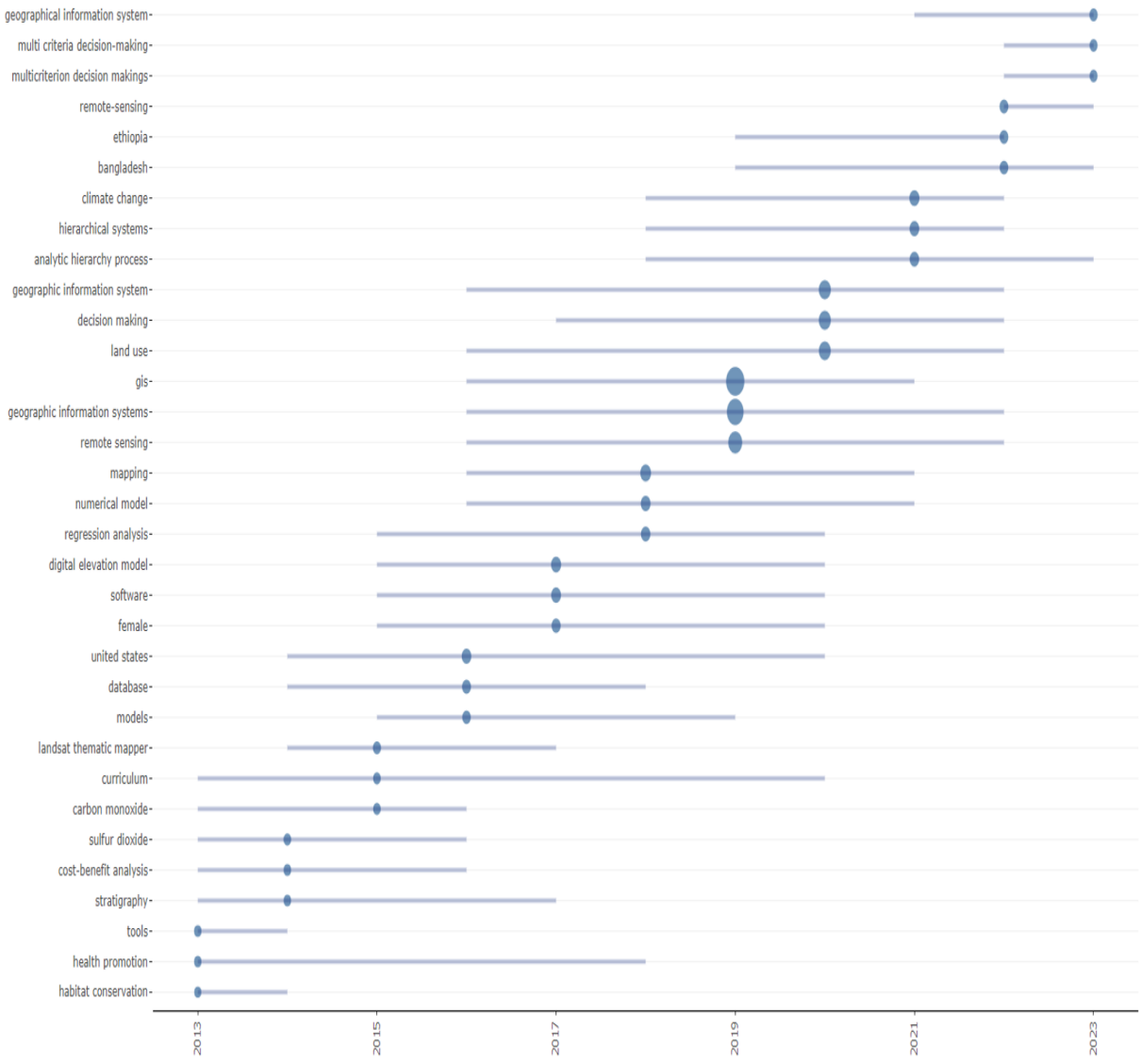


Fig. 6. Keyword popularity in publications in 2013–2023
Source: own study

Figure 7 shows a mapping of the relationships of the keywords presented earlier.

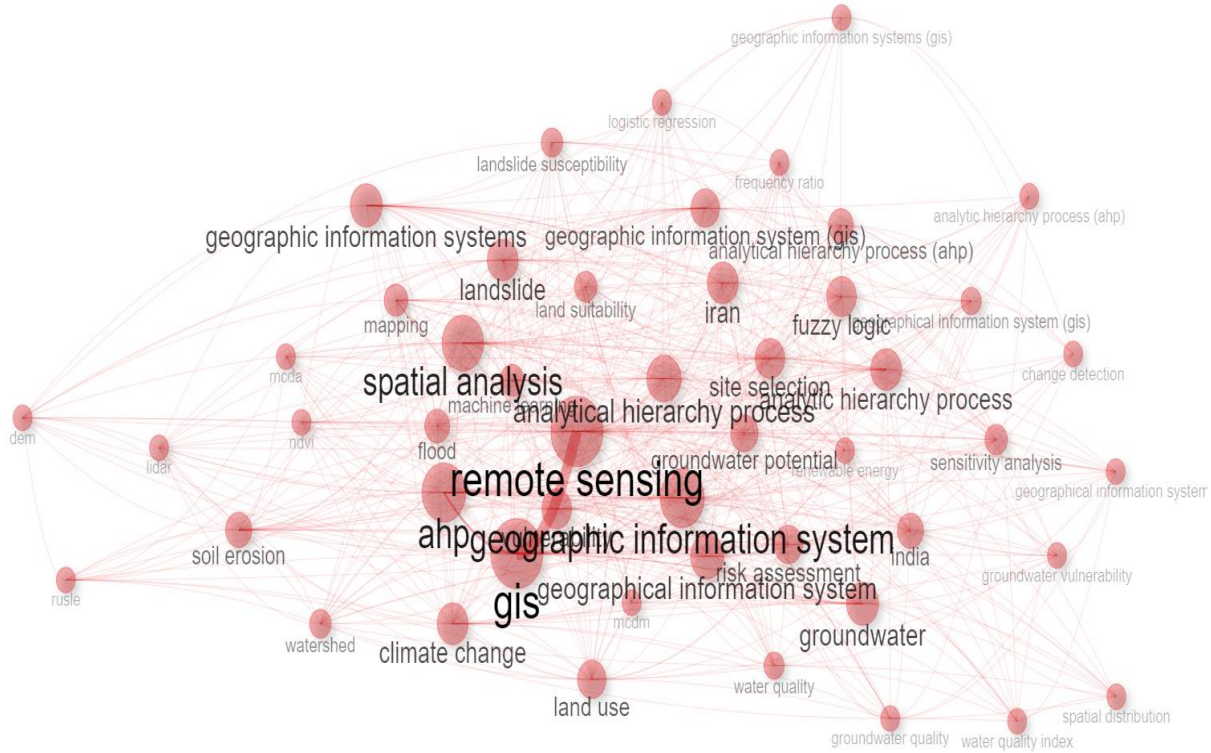


Fig. 7. Keywords relationship map of publications from 2013–2023
Source: own study

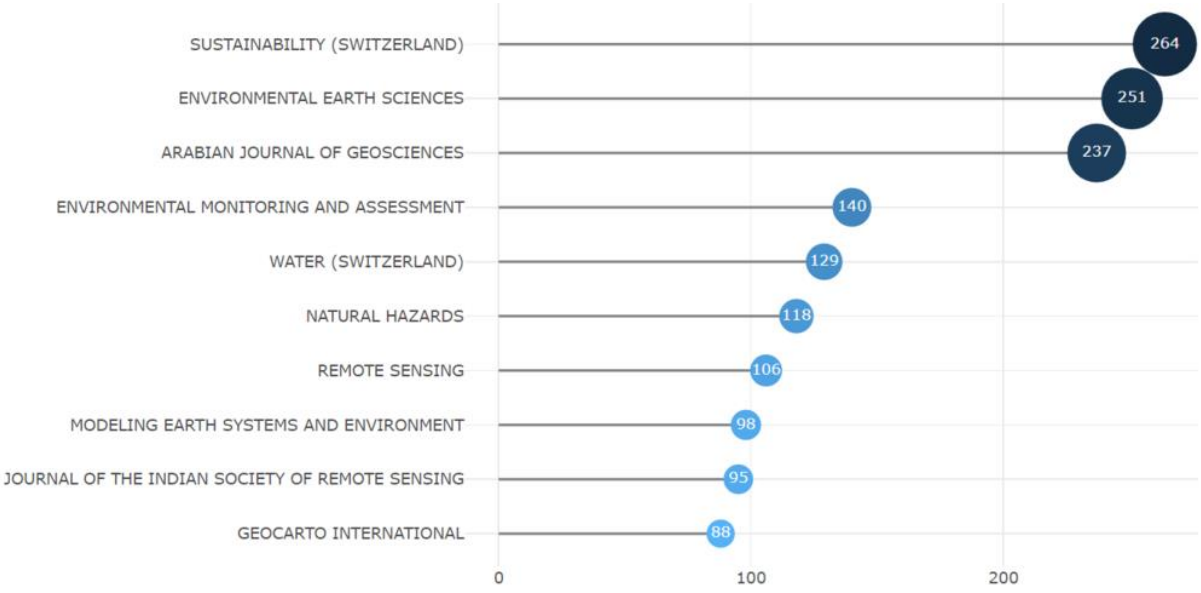


Fig. 8. Journals publishing scientific papers related to GIS between 2013 and 2023
Source: own study

Figure 8 can be a signpost for researchers seeking opportunities to publish their GIS-related work. The most popular journals are Sustainability (264 publications), Environmental Earth Sciences (251 publications), and Arabian Journal of Geosciences (237 publications). The last journal, in particular, correlates strongly with many articles from Iran or Egypt. Table 5 lists the authors with the highest number of publications in the GIS area from 2013–2023. This has the potential to help uncover authorities in that field and current research trends.

Table 5. Number of publications by author

| Autor | Frequency |
|---|---|
| Pradhan B. | 82 |
| Li Y. | 51 |
| Liu Y. | 51 |
| Wang Y. | 51 |
| Zhang Y. | 51 |
| Li X. | 47 |
| Wang J. | 44 |
| Pourghasemi Hr. | 41 |
| Wang X. | 39 |
| Zgang J. | 37 |

Source: own study

Table 6 shows the most cited scientific articles from 2013–2023 regarding GIS (Geographic Information System). The articles are essential to environmental studies, suggesting that natural resource management and sustainable development are becoming more popular. This research relates to mapping land vulnerability to landslides, evaluating soil erosion, forecasting flood-prone areas, and tracking changes in land use and water issues. In addition to GIS modeling, this work uses several different and modern computational techniques, such as decision trees, machine and neuro-fuzzy models, index of entropy, and logistic regression models. This research is relevant to land use planning and emergency management in areas of risk and flooding. At the same time, many articles focus on monitoring land use changes using GIS technology, which is related to the general direction of recent years or the study of environmental changes. The compilation of the most cited scientific papers in the area of Geographic Information Systems Provides a remarkable decision-making advantage for authors of future studies of this type. The number of citations of specific research areas indicates possible directions for applying GIS models. At the same time, these articles can significantly help develop the young scientific community just entering the path of international publications.

Table 6. The most cited scientific papers related to GIS in 2013–2023

| Autors | Year | Paper Title | DOI | Citation count |
|---|---|---|---|---|
| Pradhan B. | 2013 | A comparative study on the predictive ability of the decision tree, support vector machine, and neuro-fuzzy models in landslide susceptibility mapping using GIS | 10.1016/j.cageo.2012.08.023 | 1,021 |
| Brown J.L. | 2014 | SDMtoolbox: a python-GIS toolkit for landscape genetic, biogeographic, and species distribution model analyses | 10.1111/2041-210X.12200 | 977 |
| Tehrany M.S., Pradhan B., Jebur M.N. | 2014 | Flood susceptibility mapping using a novel ensemble weights-of-evidence and support vector machine models in GIS | 10.1016/j.jhydrol.2014.03.008 | 724 |
| Tehrany M.S., Pradhan B., Jebur M.N. | 2013 | Spatial prediction of flood susceptible areas using rule based decision tree (DT) and a novel ensemble bivariate and multivariate statistical models in GIS | 10.1016/j.jhydrol.2013.09.034 | 623 |
| Gansasri B.P., Ramesh H. | 2016 | Assessment of soil erosion by RUSLE model using remote sensing and GIS - A case study of Nethravathi Basin | 10.1016/j.gsf.2015.10.007 | 619 |
| Rawat J.S., Kumar M. | 2015 | Monitoring land use/cover change using remote sensing and GIS techniques: A case study of Hawalbagh block, district Almora, Uttarakhand, India | 10.1016/j.ejrs.2015.02.002 | 604 |
| Tehrany M.S., Pradhan B., Mansor S., Ahmad N. | 2015 | Flood susceptibility assessment using GIS-based support vector machine model with different kernel types | 10.1016/j.catena.2014.10.017 | 596 |
| Devkota K.Ch., Regmi A.D., Pourghasemi H.R., Yoshida K., Pradhan B., Ryu I.Ch., Dhital M.R., Althuwaynee O.F. | 2012 | Landslide susceptibility mapping using certainty factor, index of entropy and logistic regression models in GIS and their comparison at Mugling–Narayanghat road section in Nepal Himalaya | 10.1007/s11069-012-0347-6 | 586 |
| Sener S., Sener E., Davraz A. | 2017 | Evaluation of water quality using water quality index (WQI) method and GIS in Aksu River (SW-Turkey) | 10.1016/j.scitotenv.2017.01.102 | 587 |
| Kovzoglu T., Sahin E.K., Colkesen I. | 2013 | Landslide susceptibility mapping using GIS-based multi-criteria decision analysis, support vector machines, and logistic regression | 10.1007/s10346-013-0391-7 | 538 |

Source: own study

## Conclusions

Bibliometric methodology is receiving increased interest with highly available and applicable bibliometric software and databases. Such techniques are increasingly gaining importance with the rising field of artificial intelligence and big data (Passas, 2024). The article uses bibliometric analysis of scientific articles from 2013–2023 in the SCOPUS database related to GIS (Geographic Information System) models. This kind of analysis provides a better understanding of the GIS scientific landscape, which allows you to supplement your traditional views with the latest expert opinions and understand the current direction of this research. The study used more than 8,000 scientific papers, which gives a broad view of the methodology used, research areas, and trends and also allows you to identify potential collaborators and possible journals.

The result of the research is the definition of the most critical research areas used by the authors in their publications, which include remote sensing, land use, urban planning, urbanization, environmental monitoring, risk assessment, and water and flood diagnosis. At the same time, attention was drawn to the significant number of publications from India or China, which translated into high citations for publications from these countries. Therefore, more attention should be paid to universities in these countries as potential places for scientific cooperation or exchange. Indicating the ten most cited scientific papers can help scientists from all over the world to concretely present their research in areas that are currently considered by the world community to be the most up-to-date. Bibliometric methods can be an essential aid for scientists in preparing future scientific articles in the context of current research trends.

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