



## Scientific Roadmap: A Bibliometric Analysis of GIS Use in Aquatic Resources Management

### Hoja de ruta científica: un análisis bibliométrico del uso de SIG en la gestión de recursos acuáticos

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#### Abstract

This article presents a bibliometric analysis of research conducted on the use of Geographic Information Systems (GIS) in aquatic resource management. Using bibliometric methods, this study investigates the annual publication frequency, most relevant publication sources, most cited authors, and key research topics and trends in this field. The results show that there has been an increase in the number of publications over time, with an emphasis on topics such as water quality, the use of GIS itself, and geographic information systems. The most frequently cited authors included authors with a variety of disciplinary backgrounds, demonstrating the multidisciplinary nature of this research. The analysis also showed that there are still untapped research opportunities, especially in integrating GIS with new technologies, water management in urban areas, and research focused on developing countries. These findings provide a better understanding of the current research landscape and may assist in formulating future research directions for the use of GIS in aquatic resource management.

**Keywords:** spatial; bibliometric; trends; gis; aquatic.

#### Resumen

Este artículo presenta un análisis bibliométrico de investigaciones realizadas sobre el uso de Sistemas de Información Geográfica (SIG) en la gestión de recursos acuáticos. Mediante métodos bibliométricos, se investiga la frecuencia anual de publicación, las fuentes de publicación más relevantes, los autores más citados y los principales temas y tendencias de investigación en este campo. Se muestra un aumento en el número de publicaciones a lo largo del tiempo, con énfasis en temas como la calidad del agua, el uso del SIG y los sistemas de información geográfica. Los autores más citados incluyen autores con diversas trayectorias disciplinarias, lo que demuestra el carácter multidisciplinario de esta investigación. Oportunidades de investigación son la integración de los SIG con las nuevas tecnologías, la gestión del agua en zonas urbanas y la investigación centrada en los países en desarrollo. Estos hallazgos proporcionan una mejor comprensión del panorama actual de la investigación y ayudan a formular futuras líneas de investigación para el uso de los SIG en la gestión de recursos acuáticos.

**Palabras clave:** espacial; bibliométrico; tendencias; SIG; acuático.



## 1. Introduction

Aquatic resource management is one of the biggest challenges in the era of globalization and climate change. With population growth and increasing pressure on natural resources, the strategic role of aquatic resource management is becoming increasingly important. In this context, Geographical Information Systems (GIS) technology has shown great potential in supporting effective decision making and management strategies (Aguilar-Manjarrez et al., 2006).

GIS, as a tool capable of integrating, storing, editing, analyzing, and visualizing geographic data, has been widely used in various fields, including aquatic resource management (Bhattacharya et al., 2020; Hou et al., 2019; Orth et al., 2022; Sterling et al., 2014). Its use helps in water quality monitoring, habitat mapping, environmental impact assessment, and various other applications that support the management and conservation of aquatic resources (Brown & Vasseur, 2020; Castillo & Cruz, 2020; Kimothi et al., 2023).

However, although there is much research that has been done on the use of GIS in aquatic resource management, there has not been a comprehensive understanding of how this research trend is evolving and how this knowledge is distributed in this area. In this context, bibliometric analysis can provide invaluable insights.

Bibliometric analysis is a research method that uses data from scientific publications to analyze trends and patterns within a field of research. In this study, we will conduct a bibliometric analysis on the literature focusing on the use of GIS in aquatic resource management (Aznar-Sánchez et al., 2019; Donthu et al., 2021). Our goal is to understand key research trends, the most discussed topics, and how this knowledge has evolved over time.

Geographical Information Systems (GIS) are technologies that integrate, manage, analyze, and visualize geospatial data to aid in the understanding and interpretation of patterns and trends in a variety of geographic and temporal contexts. Key features of GIS include mapping, landscape analysis, spatial modeling, and integration of data from multiple sources. With these capabilities, GIS has become a very effective tool in many fields, including aquatic resource management (Chidumeje et al., 2015; Kale, 2018; Remillard & Welch, 1992; Wubie et al., 2016).

The relevance of GIS in aquatic resource management lies in its ability to visualize and analyze data in spatial and temporal contexts. The use of GIS enables accurate and efficient assessment of aquatic resources, including water quality monitoring, habitat

mapping, environmental impact assessment, and environmental change modeling (Johnson & Gage, 1997; Jones et al., 2017). Thus, GIS helps in evidence-based decision making, enabling more effective and sustainable planning and implementation of management strategies.

The purpose of this study is to understand and map trends and developments in the use of GIS in aquatic resource management through bibliometric analysis. Bibliometric analysis will be used to identify key themes, most prolific authors, most published journals on the topic, as well as evolution and shifting focus in research over time. As such, the study aims to provide a "scientific roadmap" of how GIS has been used in aquatic resource management and provide insight into future research directions.

The main research question to be answered through this study is: How has the research trend in the use of GIS in aquatic resource management evolved over time? What are the main themes that have been studied? Who are the authors and journals that have contributed the most to this area of research? And how has knowledge in this field evolved and changed over time? The answers to these questions will help in formulating recommendations for future research and in identifying areas that require further research.

The significance of this study lies in its ability to provide a comprehensive overview of the use of GIS in aquatic resource management based on a review of existing literature. By mapping research trends and developments, the study will help identify the main topics, the most contributing authors, as well as the most published journals in this field. A major contribution of the research is the creation of a "scientific roadmap" that will assist researchers and practitioners in understanding future research directions, highlight areas that require more research, and in general, facilitate better knowledge and understanding of how GIS can and has been used in aquatic resource management.

## 2. Methodology

### Bibliometric Analysis Methods

Bibliometric analysis is a quantitative method used to explore and understand trends and patterns in academic research through the analysis of published data. This method involves collecting, processing, and analyzing publication data from scientific databases to evaluate the development and structure of the research field, as well as identifying the main topics, the most prolific authors, and the most published journals in the field.

### Database Description and Search Criteria

For this study, we will use the Scopus database, which is one of the largest and most comprehensive scientific databases. Scopus provides access to a wide range of publications in science, technology, medicine, social sciences, and arts and humanities, making it an ideal resource for bibliometric analysis (Donthu et al., 2021). The search criteria will be focused on the use of GIS in aquatic resource management. Therefore, keywords such as "Geographical Information Systems", "GIS", "water resource management", "hydrology", and "aquatic resource management" will be used in different combinations to ensure that all relevant publications are included in the analysis. In addition, only articles and reviews published in English will be included in this analysis to ensure consistency and a good understanding of the content.

### Data Analysis Procedures and Techniques

Data obtained from Scopus will be extracted and imported into the R environment for further analysis using the bibliometrix package (Aria & Cuccurullo, 2017; Dervis, 2019). This package provides useful tools for bibliometric analysis and data visualization. In this study, we will use bibliometrix to perform descriptive analysis (e.g., publication trends over time, distribution of publications by country and journal, most prolific authors), as well as co-citation analysis and network analysis to understand the relationship between research topics.

Once the data is extracted and imported, a pre-processing process will be carried out to clean and prepare the data for analysis. It involves removing duplicate entries, keyword mapping, and data normalization. After pre-processing, data analysis will be carried out. It involves the generation of descriptive statistical indicators, network analysis, and data visualization. Network analysis and data visualization will help in identifying and understanding patterns and relationships in the data.

## 3. Results and discussion

This bibliometric study includes research conducted over a long span of time, from 1988 to 2023, showing developments and evolutions in the use of GIS in aquatic resource management over more than three decades. With a total of 167 documents produced by 633 different authors, it reflects the richness and diversity in existing research in this field. These documents come from 125 different sources or journals, indicating that the topic has been extensively researched and disseminated across various academic platforms (Table 1).

In terms of research productivity, the data shows an annual growth rate of 3.19%. This suggests that,

although this topic has been researched for decades, there is still consistent research growth over time. The average age of the documents was 10.6 years, suggesting that most of the research in this dataset is relatively new.

**Table 1**

Main Information

Description	Results
<b>MAIN INFORMATION ABOUT DATA</b>	
Timespan	1988:2023
Sources (Journals, Books, etc)	125
Documents	167
Annual Growth Rate %	3.19
Document Average Age	10.6
Average citations per doc	24.41
References	1
<b>DOCUMENT CONTENTS</b>	
Keywords Plus (ID)	1751
Author's Keywords (DE)	623
<b>AUTHORS</b>	
Authors	633
Authors of single-authored docs	10
<b>AUTHORS COLLABORATION</b>	
Single-authored docs	13
Co-Authors per Doc	4.01
International co-authorships %	15.57
<b>DOCUMENT TYPES</b>	
article	111
book	1
book chapter	11
book chapter article	1
conference paper	31
conference review	4
review	8

Descriptive analysis also shows that research in this area often involves collaboration between authors. On average, each document has 4.01 co-authors. In addition, 15.57% of the documents involve international collaboration, indicating a high level of cooperation and knowledge exchange in this area.

So far, the study has produced 1751 unique keywords used in document identification, as well as 623 keywords defined by the author. It shows the diversity and complexity of the topics studied in the context of the use of GIS in aquatic resource management.

Lastly, the data shows that the research has been published in a variety of formats, including 111 articles, 1 book, 11 book chapters, 1 book chapter article, 31 conference papers, 4 conference reviews, and 8 reviews. This suggests that research is not only limited to journal articles, but also involves various other forms of publication, including books and conference presentations.

### Annual Article Production

The dataset covers a span of 36 years, from 1988 to 2023, and illustrates the production trend of articles on the use of GIS in aquatic resource management (Figure 1).

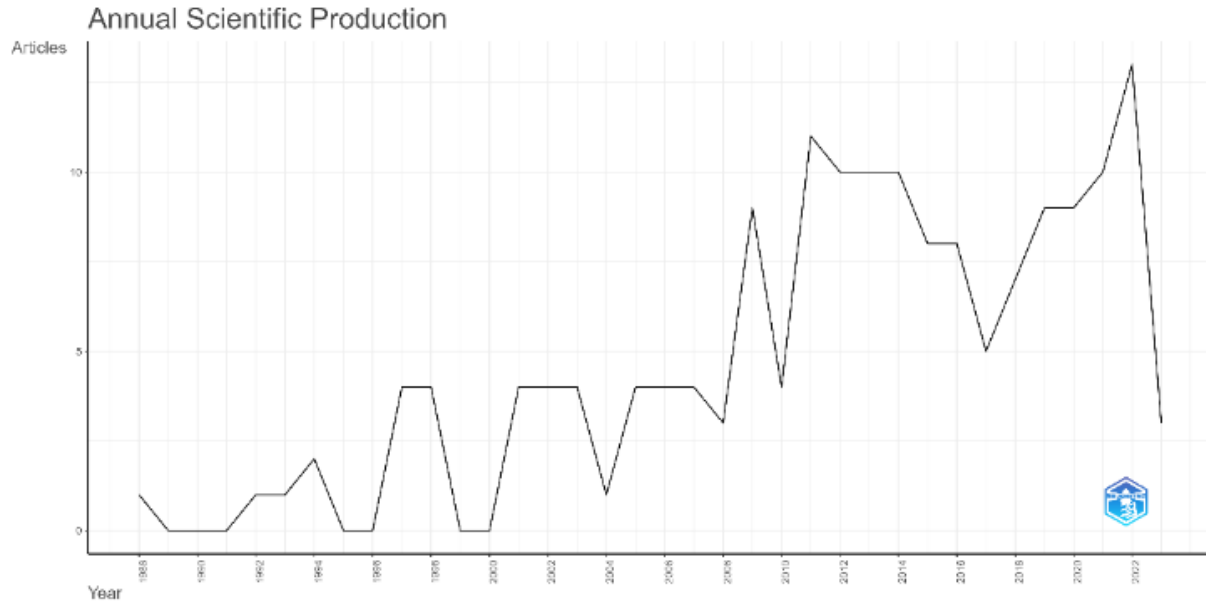


Figure 1. Annual Article Production.

Overall, the dataset shows variation in the number of articles produced each year, with a minimum number of zero and a maximum of 13 articles in a year.

On average, about 4 to 5 articles are produced each year. While this may seem relatively small, it's important to remember that this topic is very specific, and this number reflects a fairly significant volume of research in a highly specialized field.

Furthermore, descriptive analysis shows that article production seems to increase over time. The third quartile (75%) of data reached 8.25 articles per year, indicating that in recent years, article production has increased significantly.

Data visualization confirms this increase, with graphs showing an increase in article production trends since around 2000. Fluctuations in data may reflect annual variations in research, or may reflect changes in research priorities, funding, or interest in topics.

#### Relevant Sources

These sources are selected based on the number of articles they publish on this topic. Overall, each source has published between two and nine articles, with an average of about four to five articles per source (Figure 2).

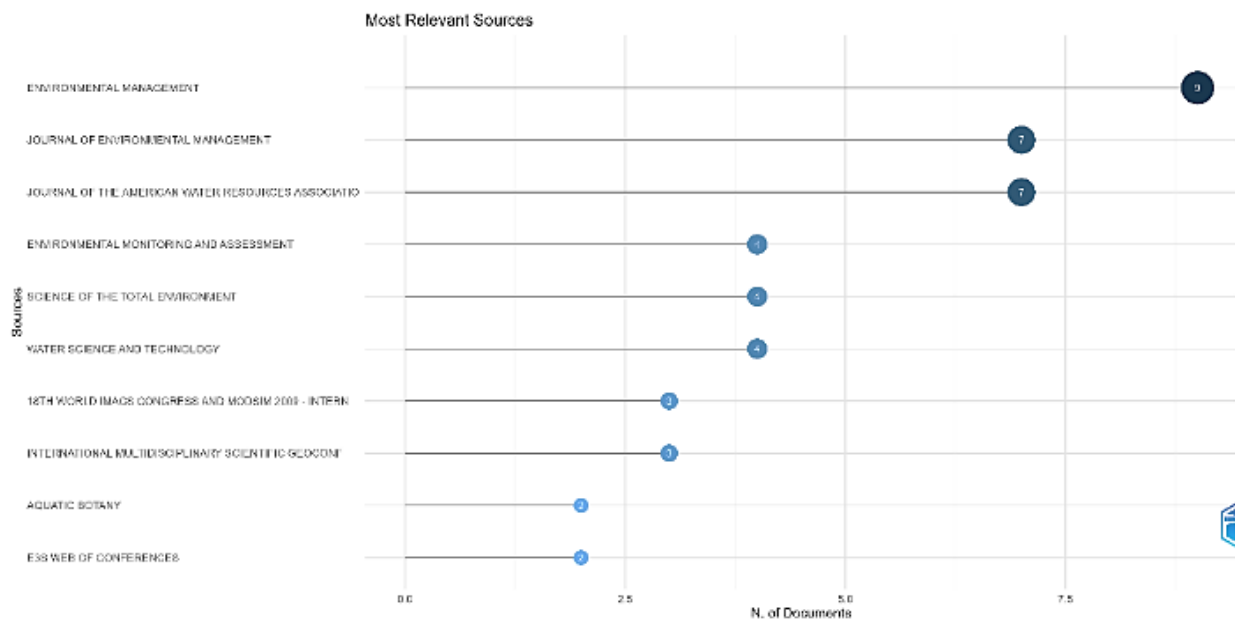


Figure 2. Relevant Source of Article.

"Environmental Management" is the most published source on this topic, with a total of nine articles. This was followed by the "Journal of Environmental Management" and the "Journal of the American Water Resources Association", each with seven articles. These sources, along with others in the top ten, represent the main publication platforms for research on the use of GIS in aquatic resource management. By looking at which sources most often publish research on this topic, we can gain a better understanding of where this research is most often disseminated and accepted.

#### Article Production by Country

These countries are selected based on the number of articles they publish on the topic. Overall, each country in this top ten has published between eight and 142 articles, with an average of about 31 articles per country (Figure 3). The United States (USA) is the country that publishes the most articles related to this topic, with a total of 142 articles. This shows that the USA has become a major research center in this field and has played an important role in the development and evolution of GIS research in aquatic resource management.

Other countries with significant article production include China, India, and Canada. Although the number of articles produced by these countries is lower compared to the USA, they still play an important role in global research on this topic.

#### Number of Citations

Each row in the dataset represents one year, and the columns include average citations per article, number of articles, average citations per year, and number of years that can be cited (Figure 4). On average, each article is cited about 40 times, indicating a significant level of recognition and impact of research in this topic. The number of articles published each year varies, with an average of about two to three articles per year. This reflects the consistent volume of research in this field. The average citation per year for articles varies, with a minimum score of 0.1 and a maximum of 9.12. This reflects variations in the impact and acceptance of articles by the research community. However, it is important to note that average citations per year tend to increase all the time, demonstrating the relevance and ongoing impact of research on the use of GIS in aquatic resource management.

Country Scientific Production

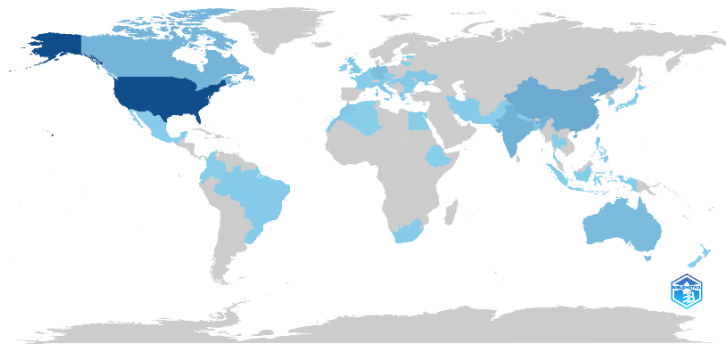


Figure 3. Article Production by Country.

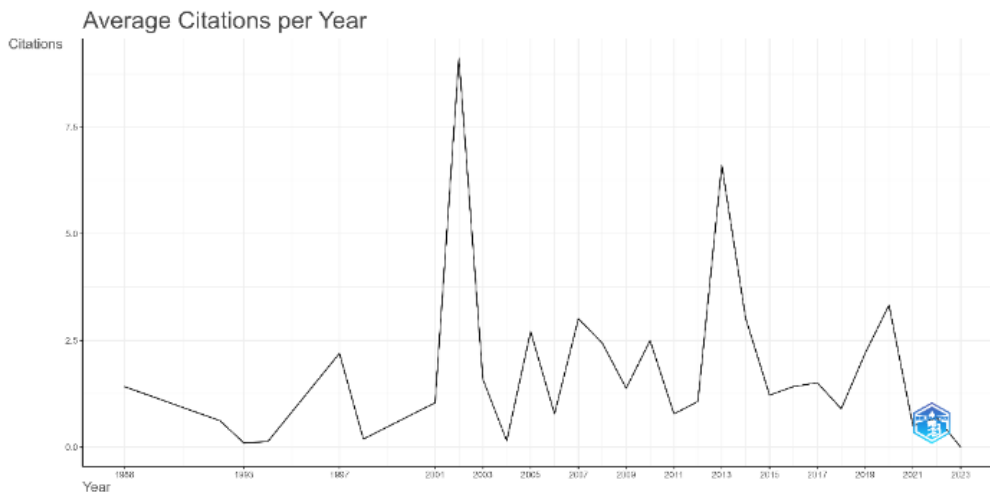


Figure 4. Number of Citations.



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