Bibliometric Analysis of Five Decades Research Progress on Boundary Delimitation
Attala Zaidan Ghaffar, Ade Gafar Abdullah, Nanin Trianawati Sugito

Abstract Boundary delimitation (BD) is essential for determining and identifying boundaries between different regions. To thoroughly understand boundary delimitation (BD) and the current research focus, this research uses a bibliometric analysis method to evaluate the most relevant themes related to BD from 1972 to 2022. This study uses the keyword "boundary delimitation" as input and relies on the Scopus database as the ideal data source for this study. To analyze the data, VOSViewer software was used to visualize a network of authors, countries, journals, and keywords. On June 8, 2023, an analysis of 611 documents from various types of scientific papers was carried out. The research findings show that in the last 24 years, there has been a significant increase in the number of publications discussing boundary delimitation (BD). The United States is a leader in BD research, with the world's most significant contribution to publications. The Journal of the Geography of Exclusion is one of the leading journals in BD publications. Keyword analysis shows that studies of BD in the last five decades have focused on topics such as maritime boundaries, the law of the sea, territory purchasing methodologies, Eurasia, and China.

Keywords: Bibliometric Analysis; Boundary Delimitation; Area Boundaries; Geospatial Analysis

1. Introduction
Boundary delimitation (BD) is an important process for determining and limiting boundaries between different areas. In the context of geography and mapping, BD has a significant role in spatial understanding and regional management. BD is defined as "the determination of the official boundaries of a region or country (Hasan et al., 2019) (Spitzer, 2021). Basically, BD involves the determination and marking of clear and legal boundaries that separate one region from another. This process involves the use of geographic data, such as maps, satellite imagery, topographical data, or other geospatial data (Jacquez et al., 2000). Various factors can be considered in BD, including geographical, political, cultural, social, economic, and legal aspects (Østhagen, 2020). In geography, BD helps understand and analyze spatial relationships between various regions. This can influence the understanding of geographic distribution patterns, interactions between regions, environmental dynamics, and administrative divisions. BD also plays
an important role in mapping, where the determination of boundaries (regional boundaries) is an important element in making maps that are accurate and informative.

In geography and mapping, BD has an important role in spatial understanding and regional management. Defining and delimiting boundaries between different areas or regions is a crucial first step in understanding geographic complexity. BD provides a clear and legitimate basis for administrative arrangements, geographic data exchange, environmental modeling, and better analysis and understanding of the area under study (Zhao et al., 2018). In the geopolitical context, BD is very important in determining territorial boundaries between countries, which has an impact on sovereignty, territorial claims, and international agreements and conflicts (Østhagen, 2020). In addition, BD also plays a role in mapping administrative areas, such as dividing districts, districts, or provinces, which affect resource allocation, public services, and development planning (Gao et al., 2022).

Research on BD has covered a wide range of fields, including political science, physical geography, geoinformatics, and environmental studies. Through bibliometric analysis, research trends related to BD can be identified, as can the contributions of leading authors or institutions in this field, as well as research focuses that still need to be explored (McBurney & Novak, 2002). By understanding past developments and research contributions, we can identify knowledge gaps that can be filled, advance methodologies, or dig deeper into BD concepts and applications. In the context of globalization and rapid environmental change, BD is becoming increasingly important in addressing challenges such as climate change, sustainability, territorial conflicts, and effective spatial planning (Dundas, 1994). Therefore, a bibliometric analysis of BD can provide valuable insights for researchers, practitioners, and decision-makers in understanding trends, current thinking, and research directions in this field and provide a foundation for the development of better policies and practices in mapping and managing regions. The main objective of this study is to analyze the development of BD research from year to year, identify the most productive researchers and countries in this field, find the most cited papers, analyze the most cited journal publishers, and conduct a co-occurrence analysis to identify relationships between topics that frequently arise in BD research.

2. Methods

This bibliometric study uses data from the Scopus database because this database provides access to a wide variety of scientific journals and sources of information across a wide range of disciplines, including geography and chaos (Guerrero-Bote et al., 2021) (Utama et al., 2019) (Magadán-Díaz & Rivas-García, 2022). The data obtained from Scopus includes publications from various authors, institutions, and countries, thus providing a comprehensive overview of the development of BD research. The data collection process was carried out on
June 8, 2023, with the keyword "limit delimitation". Through searching using these keywords, a total of 611 documents were obtained that were relevant to this research topic. The choice of data collection date is also important to ensure that this bibliometric study includes the latest publications that can reflect the latest research developments in the field of BD. In the data search process, no specific inclusion criteria were used. Therefore, the articles obtained were not only limited to English but also included articles in French, German, and Mandarin. In addition, there are no restrictions regarding the type of articles, so review papers, conference proceedings, and book chapters are also included in this analysis. This approach enables data collection that is more inclusive and broadens the scope of research in this bibliometric study, so as to provide a more comprehensive picture of the development of BD research globally.

The initial process of data processing involves cleaning stages using the OpenRefine and Thesaurus applications to eliminate unnecessary data duplication. This step aims to ensure the cleanliness and accuracy of the data used in the analysis. After the data has been cleaned, the next step is processing and visualization using the VOSViewer application to carry out a more in-depth analysis. In the VOSViewer application, keyword analysis is carried out through the co-occurrence method, which allows the identification of relationships and patterns of co-occurrence between keywords. By using the unit of co-occurrence analysis, we can gain more detailed insight into how keywords are related in the context of BD research. This helps in identifying topics that frequently appear together and understanding the relationships between related concepts in the literature. As such, these steps allow for more comprehensive data processing and informative visualizations to gain deeper insights into BD research.

In the VOSViewer application, the data that has been visualized will be represented in the form of connected nodes with variations in color and size. In co-occurrence analysis, each node in the network represents an entity or group of keywords that have something in common. This visualization provides the following information: (1) Node size indicates how often keywords appear in the dataset, with larger sizes indicating higher frequency; (2) The network between nodes represents the co-occurrence relationship between keywords, namely keywords that often appear together or are related in publications. (3) Network thickness indicates the degree of co-occurrence between keywords, with greater thickness indicating a higher frequency of keywords occurring together. Thus, the larger the node size, the more frequently the keywords occur, and the thicker the network between nodes, the higher the co-occurrence rate between those keywords. This visualization helps depict patterns of relationships between keywords and allows the identification of topics that frequently occur together in BD research.

The next stage is clustering as an enrichment technique in bibliometric analysis. The goal is to create thematic or social clusters, depending on the type
of analysis being performed. Through sequencing and observing network clusters, we can gain an understanding of the development of the research field. For example, the use of co-occurrence analysis in creating thematic clusters can reveal the main themes that shape the intellectual structure and development of the research field being studied. The next stage involves the analysis of the results, in which the authors conclude the bibliometric findings from the visualizations that have been carried out using the VOSViewer application. This analysis focuses on the distribution and relationship between each keyword, which will be explained in the results chapter. The final stage in the bibliometric analysis is to explore the distribution of related publications, including the distribution of research in various countries, research trends on BD topics from year to year, and grouping by subject area.

3. Results and Discussions

Figure 1 shows the development of research productivity on BD in the range of 1972 to 2022. In 1972, the Annals of the Association of American Geographers published the first paper on the issue entitled “The Epsilon Generalization,” written by Rechlin (Rechlin, 1972). The paper proposes an accurate and precise method for identifying and describing various forms of settlement, especially in cases where community forms are unclear and difficult to define. However, from 1972 to 1992, the development of scientific publications on BD was not very significant. However, from 1998 to 2005, there was a rapid increase in the number of scientific publications on the topic, with an average of 24 papers published each year. The 2006–2022 range shows fluctuations in the development of scientific publications on BD, with the number of publications per year ranging from 9 to 30 papers, with an average of 20 papers per year. In general, many of these papers are published in scientific journals in the social sciences, earth and planetary sciences, and environmental sciences. In terms of document types, 611 publications were categorized into research articles (80.20%), review articles (7.86%), book chapters (6.22%), conference articles (3.44%), books (1.96%), conference reviews (0.16%), and notes (0.16%).

![Figure 1. Development of scientific publication productivity in boundary delimitation (BD) research for fifty years](image-url)
Figure 2 shows a visualization of the most productive countries in BD research. In the context of research output productivity and inter-country networks in relation to boundary delimitation (BD), the United States occupies the leading position with the highest number of publications on BD, namely 102 documents (16.69%). Followed by England with 91 documents (14.89%), and China with 54 documents (8.84%). Not only in terms of the number of publications but also in terms of citations, articles originating from the United States and the United Kingdom have been cited more than those from other countries. Southeast Asian countries also made significant contributions, especially Singapore with 13 documents (2.13%) and Indonesia with 7 documents (1.15%). In terms of network strength, the United States engages in close collaboration with Canada and China. Meanwhile, the UK is cooperating with Canada, Taiwan, China, and Australia. Taken together, these facts highlight the leading role of the United States and the United Kingdom in BD research but also recognize the important contributions of Southeast Asian countries. In addition, information about the strength of the network suggests collaborative relationships that can potentially support knowledge exchange and research progress in the BD field.

![Figure 2. Network visualization of the most productive countries in the boundary delimitation research output](image)

Figure 3 shows the publication map of the results of the analysis of citation data based on the author's publications that are most often cited in other publications. From the data that has been analyzed, the results are eight clusters with 27 items and 44 links, where the red, green, and blue clusters are the clusters with the most items, consisting of four authors. Each cluster...
shows the linkages of each author to publications that explore similar research subjects. In addition, these clusters are close to each other and are grouped, which shows that these clusters have a high probability of being quoted in the same situation. While the line or link shows the strength of the publication cited by other authors' publications. The top five authors whose publications have been cited by other publications include Keyuan (181), McDorman (124), Schofield (83), Van Dyke (74), and Huang (136). Keyuan's widely cited paper discusses the recently ratified Sino-Vietnam boundary delimitation agreement in the Gulf of Tonkin and its implications for bilateral cooperation and the growth of friendly and neighborly relations between China and Vietnam. The delimitation in the Gulf of Tonkin, which is the first maritime boundary line for China, shows China's willingness to cooperate with Vietnam and other neighbors to resolve other maritime disputes (Keyuan, 2005). McDorman's paper, which has received many citations, published the results of a study that examined the role played by the Convention on the Law of the Sea when a coastal state tried to define the outermost boundaries of the continental shelf in accordance with the provisions of the convention. The argument in this paper is that the main role of the Law of the Sea Commission is as a legitimizer of coastal state claims, and that this role is quite modest in an inherently political boundary-making process (McDorman, 2002). Schofield's multi-cited paper discusses issues related to the delineation of maritime boundaries between Malaysia, Singapore, and Indonesia. This article provides a summary of the case, including consideration of baselines, each party's claims to maritime jurisdiction, and the delimitation of the sea. Focus is given to the status and potential role of islands in this context. Then, this article also evaluates and considers potential scenarios for the delimitation of sea boundaries east of the Singapore Strait (Beckman & Schofield, 2009).
By using data that has been processed from 157 sources, it was found that 12 of them had at least five documents. Figure 4 depicts a co-citation network based on sources cited by other publications. The results of the analysis show that there are 12 clusters with 42 items and 70 links. The figure's links or lines show how frequently other publications cite the sources, and the grouping based on clusters describes how these sources relate to one another in the same research context or related fields. Journal sources most frequently cited by other publications are Geographies of Exclusion (2251), Ocean Development and International Law (536), Political Geography (513), International Journal of Marine and Coastal Law (457), and Environment and Planning D: Society and Space (438). These sources are marked with the largest node size in the image.

Figure 4. Visualization of scientific publications on the theme of boundary delimitation

To confirm the scope of work and main topics in research related to boundary delimitation (BD), it is important to test each document and identify the main keywords. This analysis has the importance of revealing trends in emerging themes and identifying areas of interest for research, development, and innovation. In the analysis of keywords related to BD, a total of 1000 results were found. However, only 192 (19.2%) of these results met the requirements with at least five co-occurrences, as shown in Figure 5. Based on the distribution of keywords, there are five clusters, which are divided into the first cluster relating to "maritime boundary", cluster two dealing with the issue of "law of the sea", cluster three dealing with "methodology", cluster four dealing with the theme "Eurasia", and cluster five dealing with the theme "China".
In the first cluster on maritime boundaries, the dominant keywords relate to the research issues "continental shelf", "delimitation", "exclusive economic zone", and "maritime boundary delimitation". Maritime boundary delimitation is very important in understanding the complexity of issues related to state sovereignty, the utilization of natural resources, and environmental protection in international waters. International law plays a central role in resolving boundary and maritime boundary disputes between nations that share the waters. One of the important aspects of delimiting maritime boundaries is the understanding of continental basins, which refer to the extension of the continent below sea level and have rich natural resource potential. States have the right to claim their continental basin territory based on relevant principles of international law (Magnússon, 2015b, 2015a).

Delimitation, as the process of delimiting maritime boundaries between adjacent countries, is a complex issue that requires a deep understanding of international law. This process involves careful legal and technical thinking in determining equitable boundaries and taking into account the interests of both parties, including exclusive economic zone rights and associated natural resources (Árnadóttir, 2022; Daddy, 2019).

The exclusive economic zone (EEZ) is a water area recognized by international law where the coastal state has the exclusive right to manage and utilize the natural resources, both living and non-living, within it. When delimiting maritime boundaries is carried out, the EEZ becomes an important consideration for determining the exclusive rights and obligations of the countries involved (Gaver, 2022; Haider, 2022; Ishii, 2020). In the context of maritime boundary delimitation, a clear and firm boundary delimitation process is very important. Appropriate delineation of maritime boundaries in
accordance with international law can help reduce the potential for conflict and promote mutually beneficial cooperation among nations that share the waters. It is important to apply principles of equitable international law, such as the principles of fairness and balance, in the process of delimiting maritime boundaries (Cottier, 2015b; Jaya et al., 2022). Overall, the delimitation of territorial or maritime boundaries is a complex issue in international law. In this context, a deep understanding of continental basins, boundary delimitation, exclusive economic zones, and maritime boundary delimitation processes is essential to resolving disputes and reaching a just and sustainable solution for all parties involved.

In the second cluster, themes related to the "law of the sea" related to issues of the United Nations, dispute resolution, dispute settlement, marine environment, and fisheries. Limitation of territorial boundaries or maritime boundaries, known as "boundary delimitation," is an issue that is closely related to the "law of the sea." The law of the sea is the legal framework governing various aspects of the use, utilization, and protection of resources in international waters. In the context of boundary delimitation, the law of the sea serves as a guide in determining boundaries that are just and consider the interests of all the countries involved (Cottier, 2015a). The importance of delimiting boundaries within the framework of the law of the sea has been widely recognized by the international community, including the "United Nations" (UN). The UN plays an important role in facilitating dialogue between countries and providing a framework for dispute resolution. This organization supports peaceful negotiation and dispute resolution through mechanisms such as "dispute resolution" and "dispute settlement" regulated by the law of the sea (Haider, 2022). In delimiting territorial boundaries, attention is also given to the protection of the marine environment. The law of the sea encourages countries to consider the impact of boundary delimitations on the "marine environment" and take necessary actions to protect and maintain the sustainability of marine ecosystems (Keyuan, 2021; Maina et al., 2019). In addition, the fisheries sector is also an important aspect of boundary delimitation. Countries should consider the sustainability of fish resources and rights related to fishing activities in the process of demarcating their boundaries. The law of the sea provides a framework for sustainable fisheries resource management and international cooperation in this sector (Kadagi et al., 2020).

The third cluster collects key words related to methodologies such as taxonomy, mapping, spatial analysis, political boundaries, and land planning. Taxonomy, which involves classification and the grouping of different elements, plays an important role in delimiting boundaries. This helps in identifying relevant factors, such as geographic features or historical context, that influence the delimitation. Mapping is an important tool in boundary delimitation because it provides a visual representation of physical features and territorial divisions. Accurate and detailed maps allow precise
demarcation of boundaries, considering factors such as topography, waterways, and human settlements (Eng et al., 2010). Spatial analysis, on the other hand, uses geographic information systems (GIS) and analytical techniques to study specific spatial relationships and patterns. This helps in evaluating the impact of different factors, such as population distribution or resource availability, on boundary demarcation decisions (Qiwei et al., 2015). Political boundaries, including national borders and administrative divisions, are important considerations in demarcating borders. These boundaries reflect the political conventions and historical context that shaped the process of delimitation (Østhagen, 2021). In addition, land planning plays a role in delimiting boundaries by considering land use patterns, zoning regulations, and urban development. This helps ensure that boundaries align with effective land management strategies and support optimal land use (Partridge et al., 1973).

The fourth cluster collects themes related to BD issues in Europe, especially Germany, as well as the disciplines of regional geography (regional geography), history (historical geography), and politics (historical geography). Europe, as a continent that has many countries side by side, requires clear and accurate boundaries to regulate relations between countries and determine the sovereign territory of each. Boundary delimitation is important in the European context because it allows countries to ensure security, stability, and peace in the region. Germany has played a significant role in delimiting Europe, given its position as a country at the center of the continent and its shared borders with many neighboring countries. Proper and well-understood boundary demarcation is essential for Germany to maintain good relations with its neighbors and ensure the security of its territory (Danaher, 1984) (Wyžlic, 2020).

In the discipline of regional geography, boundary delimitation is an important aspect of understanding and analyzing regional dynamics. Through an understanding of boundary boundaries, regional geographers can investigate the influence of regional boundaries on the economic, social, cultural, and political development of a region (Shaban & Khan, 2022). This helps in understanding regional differences, interactions between regions, and possible regional development policies. In the historical context of geography, boundary boundaries reflect regional changes over time. Through the analysis of historical boundaries, geographers can study political changes, changing boundaries, and conflicts and treaties involving certain areas (Bakk, 2020; Grishin, 2023; Marek, 2020). It provides important insights into the historical development of a region and its influence on present-day developments. In the field of political geography, boundary delimitation plays a major role in studying the relationship between political power and geographic space. Changes in political boundaries can reflect the political dynamics and forces that exist in a region. Political analysis of geography helps in understanding the factors that influence boundary delimitation, including government policies, political forces, and societal
political demands (Jeeva & Cilliers, 2021).

In cluster five, key words related to the theme of BD in Asia are collected, especially in China, Korea, and Japan. Other issues relate to marine policy and the Pacific Ocean. Boundary delimitation has important implications in Asia, especially in China, Korea, and Japan (Davenvort, 2014). The Asian region, especially around the Pacific Ocean, is complex and has a high potential for regional conflict. Boundary delimitation is a significant issue among these countries, as it has a direct impact on sovereignty claims, natural resources, and strategic interests in the East China Sea, South China Sea, and Pacific Ocean. China, Korea, and Japan are the main actors in delimiting boundaries in this region. Differences in views, territorial claims, and understandings of legal boundaries can lead to tensions and conflicts between these states (Kittichaisaree, 1988). Boundary delimitation is important to overcome disputes and reach mutually beneficial agreements (Hasan et al., 2019; Magassing et al., 2018). Another issue related to boundary delimitation in Asia is marine policy and the Pacific Ocean. Countries in this region have great strategic and economic interests related to the utilization of marine resources, environmental protection, maritime security, and international trade. Boundary delimitation plays an important role in setting maritime policy and ensuring resource sustainability and environmental protection in the Pacific Ocean. In this context, regional cooperation and diplomacy efforts are important to reach an agreement regarding the delimitation of boundaries in Asia. Negotiations conducted by the countries of China, Korea, and Japan, as well as active participation in regional frameworks such as ASEAN, the East Asia Summit, and the Asia-Pacific Economic Cooperation Forum (APEC), can facilitate constructive discussions and peaceful resolution.

4. Conclusion

This study provides an overview of the main themes related to boundary delimitation (BD) that have been researched for five decades. The trend is the continued growth of BD-related publications each year, indicating that this theme is gaining increasing popularity. The United States currently stands out as the country with the most BD-themed publications, equivalent to 16.69% of publications in the world. The Journal of Geographies of Exclusion is the leading publishing journal in this field. In general, the major journals that publish studies on BD are multidisciplinary or interdisciplinary. Based on the analysis of the most cited keywords, we identify maritime boundary delimitation as one of the main themes that is widely discussed in various scientific articles. The researchers focused on discussing this maritime boundary study from the perspective of international law and the exclusive economic zone. Future research themes tend to lead to themes that connect the issue of boundary delimitation with aspects of environmental protection, coastal area management, and international courts. We recommend researchers in Indonesia participate in discussing these hot issues.
References


Magnússon, B. M. (2015a). *4 Delimitation of the Continental...*
Bibliometric Analysis of Five Decades Research Progress on Boundary Delimitation


Utama, Y. J., Setiyono, B., Jamari, Tauviqirrahman, M., & Susanto, H. (2019). Bibliometric Analysis of...
