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THE ANNALS OF "VALAHIA" UNIVERSITY OF TARGOVISTE

A DECADE OF BIBLIOMETRIC ANALYSIS OF BIODIVERSITY

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Abstract

Bibliometric analysis is a significant method used in scientific research to evaluate extensive and rich areas of specialized research. This study explored biodiversity as the main focus, using bibliometric data from the ScienceDirect and Scopus bases. The analysis found 1115 appearances for the keyword "biodiversity" in the top 10 specialized journals, highlighting journals such as "Biological Conservation" and "Science of The Total Environment". The clustering of keywords illustrated seven interest groups, highlighting biodiversity, the Romanian context, forestry, climate change and conservation. The time analysis also revealed the thematic evolution of the research, moving from morphology and nitrogen issues to topics such as conservation, climate change and environmental protection. Despite the usefulness of bibliometric analysis, it brings up the limitations and precautions required in the use of bibliometric data, highlighting the importance of a rigorous data cleaning process. It is also stressed that bibliometric analysis is better suited for short-term forecasts than for overly ambitious conclusions about long-term impacts. However, this method is a useful tool for specialized research, facilitating the development of knowledge in various areas of interest.

Keywords: biodiversity, bibliometric analysis, environment

1. INTRODUCTION

In recent years, bibliometric analysis has gained huge popularity in specialized research, according to researchers [18], [16], [23]. This popularity is due to the advancement of technology and accessibility of literature review software such as Gephi, Leximancer and VOSviewer, as well as scientific databases including Scopus and Web of Science, as well as the expansion of bibliometric methodology from information science to specialized research.

In addition, bibliometric analysis is very popular, in specialized research it is not an ephemeral trend, but a reflection of its usefulness for manipulating large volumes of scientific data and generating a significant impact on research. A variety of researchers use bibliometric analysis for various purposes of reasons, including discovering changes in article and journal performance, collaborative models, and research building blocks, as well as to study the cognitive structure of a particular field in the existing literature, according to researchers [18], [37], [16].

The information required to perform bibliometric analysis is often voluminous (for example, hundreds or even thousands of elements) and unbiased (such as the number of publications and citations, the appearance of keywords and topics). However, interpretations of bibliometric analysis are based on both objective assessments (e.g. performance appraisal) and subjective assessments (e.g. thematic review), established by techniques and procedures based on the researcher's experience.

Bibliometric analysis is useful for deciphering and mapping the accumulated scientific knowledge and the subtle evolution of established fields, thus making the significance of large volumes of unstructured data rigorously structured. Thus, well-conducted bibliometric studies have the potential to lay solid foundations for new and significant advances in a field. They enable and enable scientists to get a single overview, identify knowledge gaps, get new ideas for research and position their expected efforts in the field.

Bibliometric analysis has its advantages, but it still remains a relatively new method in specialized research and is often not fully exploited. This is because many bibliometric studies use a small amount of bibliometric data and methods, providing only a fragmented understanding of the field being studied. For example, a performance analysis without scientific mapping [10]. It is important to note that, in specialized research, an authoritative guide for bibliometric analysis is missing, which represents a significant challenge for specialized researchers interested in bibliometric methodology and its application holistically and understandably. While authoritative guides are available for comprehensive literature reviews (e.g. [28]; [33]), they do not provide sufficient coverage of bibliometric methodology.

Given the limitations identified above, the objectives of this paper are an introduction to bibliometric methodology and basic instructions for using bibliometric analysis in specialized research.

This paper is dedicated to introducing bibliometric analysis for business scientists, providing the necessary foundation, techniques, and procedures, along with examples and explanations.

This work has multiple contributions. First, it provides a summary of bibliometric analysis as well as instructions for its implementation, thus helping researchers learn about bibliometric methodology and apply it to evaluate specific areas of existing literature using large corpora of bibliometric data. Second, this paper provides guidance on different moorings for bibliometric analysis and when they should be used. This gives scientists a broader insight into the choices available and the motivation behind using them.

Overall, this paper contributes to a better understanding of bibliometric methodology in academic research, promoting clarity and rigor, and at the same time paves the way for researchers to use bibliometric analysis

appropriately, meaningfully, and rigorously in their future studies. In this section, the aim of the research is to provide a detailed introduction and fundamental instructions for bibliometric analysis in the field of specialized research, especially in relation to biodiversity. The article aims to achieve various objectives:

Research goal: The main goal is to familiarize biodiversity researchers with the methodology of bibliometric analysis and to provide guidance and practical instructions for its use in evaluating the research field.

Research novelty: This paper proposes a comprehensive introduction to bibliometric analysis applied in the field of biodiversity. It brings a unique perspective on how this method can be exploited to assess and map scientific knowledge and the evolution of the field, thus providing researchers with essential tools to better address and understand this area of study.

Research usefulness: The article provides essential tools, techniques and procedures for researchers wishing to use bibliometric analysis in their biodiversity studies. This paper provides a solid foundation to learn and correctly apply bibliometric methodology in exploring and evaluating the field.

This research makes significant contributions:

It provides a deeper understanding and correct application of bibliometric analysis in biodiversity studies. It highlights the various approaches and reasons why bibliometric analysis should be used in the field, providing a broad perspective on its potentials. It promotes clarity, rigor and appropriate use of bibliometric analysis, thus paving the way for moremeaningful and rigorous research in this area.

This research is crucial for biodiversity researchers, providing them with an essential guide to using bibliometric analysis properly and to gain a comprehensive perspective of the evolution and knowledge gained in the field.

2. MATERIALS AND METHODS

Bibliometric methodology practices quantitative techniques such as bibliometric analysis, citations, and publication units to analyze bibliometric data [9]; [30]. Bibliometry has been discussed since the 1950s [38], but this field has evolved somewhat recently. This claim is supported by the increasing number of papers published in this field in recent years, with a particular focus on management, business, economics, accounting, econometrics, finance and social sciences. This increase is a consequence of the expansion of scientific research (Figure 1). But large bibliographic data have made revision methods difficult to apply [31]. With scientific databases such as Scopus and Web of Science, it is much easier to procure suggestive amounts of bibliometric data. In addition, bibliometric software such as Gephi, Leximancer and VOSviewer have allowed for a more efficient and ingenious analysis of this data, which has led to an improvement in the academic level of current interest in bibliometric analysis. Bibliometric methods have been applied to investigate a wide range of specialized research areas, including business strategy, e-commerce, finance, human resources, management, and marketing. Publication analysis, collaborative prototype analysis, and research into the intellectual structure of the field in question are some of the possible applications of the process. This area of research is likely to be published in journals; The Journal of Business Research is an example of a journal that usually appears in reference years [16].

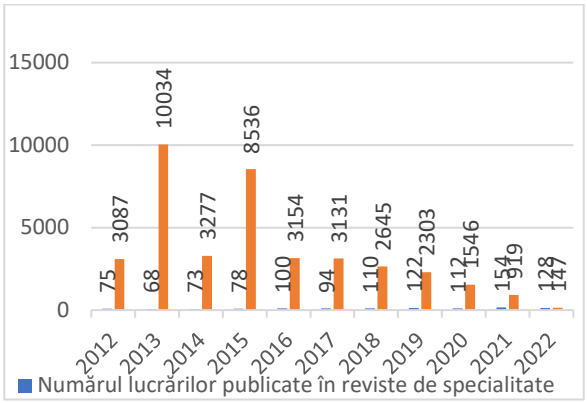


Figure 1. Evolution of publications and number of citations during 2012-2022. Source: These figures represent the trend of publication of bibliometric works between 2012 and 2022. The data was taken from the ScienceDirect database in the fields of environmental science, agricultural and biological sciences, veterinary sciences and veterinary medicine, social sciences using the keyword "biodiversity"

Following Figure 1 we can see that in 2013 and 2015 there is the greatest amount of information about selected works between 2012 and 2022, and the year with the fewest citations being 2022. Currently, bibliometric analysis is subject to comparison with other common methods of literature synthesis, such as meta-analysis and systematic literature reviews.

The meta-analysis aims to assess two main aspects: first, "the overall strength and direction of effects or relationships" and, second, "the variation between studies in the distribution of effect size estimates and the factors explaining this variation." [3]. On the other hand, systematic literature reviews, such as those based on field, method, and theory, involve the systematic acquisition, organization, and evaluation of existing literature applying specific methods [28]; [36]. Researchers typically perform these procedures manually (e.g., content and thematic analyses) [24]; [25]. Meta-analysis, like bibliometric analysis, has the ability to handle an appreciable amount of literature and provide a detailed picture for a particular field. However, the selection of literature considered may be less varied and significant variation between studies or the possibility of excluding new data influences the validity of results obtained through the meta-analysis [2]; [21]. On the other hand, systematic reviews of literature that rely on traditional methods often focus on narrower research areas, leading to a more limited number of papers being included in the review (e.g. between 40 and 100 to 300) [33].

For narrower research areas, such as customer engagement on social media platforms, or niche areas, such as online influencer marketing, systematic literature reviews prove to be more appropriate. Bibliometric analysis and meta-analysis are based on quantitative approaches and have the capacity to replace or reduce the need for systematic literature review, which usually focuses on qualitative methods, which may be affected by interpretative guarantees of researchers from different academic backgrounds [27].

Due to their quantitative nature, researchers can be confused about the differences between meta-analysis and bibliometric analysis. To clarify this distinction, scientists should note that although both address large amounts of literature, their quantitative approaches differ significantly in usage. For example, meta-analysis is often used to investigate open-ended research questions, providing data closer to definitive conclusions than those presented in a single central study. It focuses in particular on synthesizing empirical evidence by analyzing the direction and intensity of effects, as well as relationships between variables [11]. This method is used to elucidate conflicting empirical findings and reveal extreme circumstances.

Toolkit for bibliometric analysis technique

Performance analysis and scientific cartography are the two main categories of procedures used in bibliometric analysis. Scientific mapping examines how different components of research interact, while performance analysis focuses on the contributions of research constituents.

Performance analysis

Performance review involves evaluating researchers' contributions in a particular field [13]; [31]. According to [19], this analysis is descriptive. Even in reviews that do not have scientific mapping as their primary objective, performance analysis is used to highlight the performance of different research actors, such as authors, institutions, countries, and scientific publications. This is similar to presenting participants' background or profile, but involves a greater degree of analysis in the context of empirical research. Performance analysis recognises the relevance and contribution of different elements to a field of research, even if it is a predominantly descriptive method.

Cartographic analysis of research

Cartographic analysis of research refers to the examination of relationships between constituent elements of research, especially mental interactions and structural relationships. This analysis uses methods such as co-citation analysis, co-word analysis, bibliographic binding, co-author analysis, and citation analysis. By exposing the bibliometric structure and intellectual aspects of the research field, these techniques become crucial, especially when used in parallel with network analysis.

Citation analysis

A crucial technique for mapping scientific fields is citation analysis, which is based on the premise that when one publication refers to another, intellectual connections are created between research publications [6]. This analysis estimates the impact of a publication based on the number of citations it has received. This is a method of identifying the most influential publications in a field of research. Citation is the most direct and objective way of measuring impact, although there are other means of assessing the importance of publications in a field of research, such as network metrics [29]; [34]. In conclusion, citations can be useful for analyzing high-impact publications in a particular field of research, facilitating understanding of their distinctive intellectual evolution.

Co-citation analysis technique

Co-citation analysis is a scientific mapping technique that is based on the premise that frequently cited publications address similar topics [20]. This technique can be used to reveal the intellectual structure of a field of research as well as the fundamental themes addressed in it [26]. When two publications appear together in the reference list of another publication, they are connected through this network. Co-citation analysis has the advantage of helping researchers discover thematic groups and the most influential publications [32]. However, it is important to note that co-citation analysis is limited to publications that are highly cited and does not take into account recent or niche publications in thematic groups. Therefore, co-citation analysis is an appropriate method for scientific scientists who wish to discover seminal publications and foundations of knowledge, but may be limited in terms of discovering newer or lesser-known publications in a field of research.

Bibliographic coupling

The concept that publications sharing bibliographic sources are also similar in content is the foundation of scientific mapping techniques called "bibliographic coverage" [22]; [39].

This method uses common references to divide publications into thematic groups and is most effective within a given timeframe [41]. Unlike co-citation analysis, this method argues that recent and niche publications can gain visibility by forming thematic clusters based on common references.

Common word analysis

Unlike the previous three methods, co-word analysis focuses on publications. As it identifies keywords in titles, abstracts, and full text, this technique analyzes the actual content of the paper.

The method assumes that ideas that frequently appear together have a thematic relationship with each other. However, there are also negative aspects, such as the need to consult several works to decipher the meaning of connections between words and the difficulty of assigning very general words to a certain thematic category.

Co-word analysis can be used in a strategic manner, despite these difficulties.
Since common themes in publications tend to be relatively general, it is a welcome idea to use this supplement to improve understanding of thematic clusters resulting from co-citation analysis or bibliographic linking. To anticipate further research in the field, another suggestion is to use analysis to identify meaningful keywords from the publication's findings and indications of future research directions. Therefore, keyword analysis can provide early insight into the evolution of the research field. It is also useful for business researchers who want to improve their understanding of co-citation analysis or bibliographic references and anticipate future trends.

3. RESULTS AND DISCUSSIONS

Bibliometric analysis of the keyword "Biodiversity"

Searches of the ScienceDirect and Scopus databases revealed a number of significant findings related to the keyword 'biodiversity'.
The results are presented in Table 1 and provide insight into the specialised journals with the most occurrences related to biodiversity.

Common keyword	Magazine	Appearances
Biodiversity	Agriculture, Ecosystems & Environment	89
Biodiversity	Biological Conservation	270
Biodiversity	Ecological Economics	54
Biodiversity	Ecological Indicators	232
Biodiversity	Forest Ecology and Management	100
Biodiversity	Journal of Cleaner Production	28
Biodiversity	Journal of Environmental Management	85
Biodiversity	Land Use Policy	79
Biodiversity	Marine Pollution Bulletin	33
Biodiversity	Science of The Total Environment	145

Table 1. Top 10 specialized magazines. Source: Developed by authors using data obtained from ScienceDirect database

These results highlight a total of 1115 occurrences for the keyword "biodiversity" in the monitored journals.

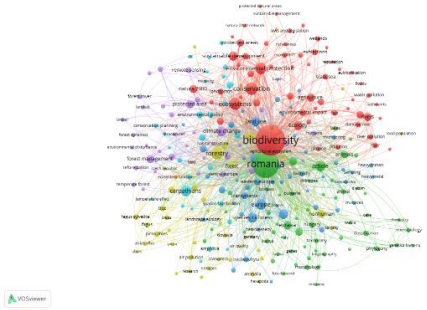


Figure 2. Cluster map of biodiversity-related words. Source: Scopus results processed by authors using VOSviewer software

Analysis of Biodiversity Associated Clusters
The cluster map (Figure 2) highlights seven distinct clusters related to biodiversity and associated domains. These are:
Cluster 1: Focuses on environmental impact, discussing issues such as forestry, climate change, ecosystems, environmental conservation and protection.
Cluster 2: Articles on biodiversity published in Romania focus on keywords such as forestry, ecosystems and environmental protection.
Cluster 3: Highlights forestry in the context of biodiversity, highlighting topics such as climate change, ecosystems, environmental conservation and protection.
Cluster 4: Starts from the benefits of biodiversity, discussing sustainable development, water quality, forest management and landforms.
Cluster 5: Focuses on conservation, environmental protection, sustainable development, landforms, protected areas and ecology.
Cluster 6 and 7: Addresses legislation, environmental impact and species diversity, highlighting the need for a holistic approach.

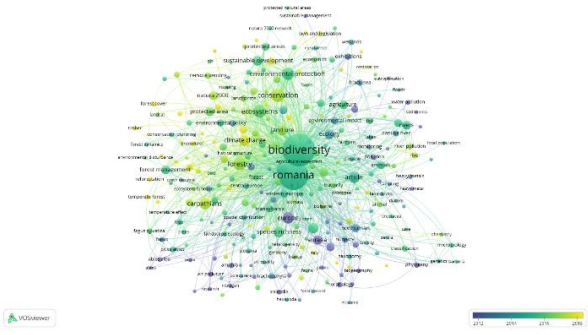


Figure 3. Dynamics of fundamental research topics over time. Source: Scopus results processed by authors using VOSviewer software

Figure 3 illustrates a temporary evolution of biodiversity-related research topics. There is a shift in focus over time, from themes such as morphology and nitrogen in 2012, to conservation, species diversity and finally to climate change, forestry, environmental protection and protected areas. Soil health characteristics are identified as crucial when addressing biodiversity.

Data source analysis numbers

For bibliometric analysis and identification of relevant information, 238 research sources and publications were retained for evaluation.

These results highlight not only the frequency of the keyword 'biodiversity' in the monitored publications, but also the key connections between biodiversity and areas of interest, as well as the evolution of research topics in this area over the years.

The criteria for inclusion and exclusion from the bibliometric analysis are essential to ensure the validity and relevance of the results obtained. These criteria help define the selection of data and sources to be analysed, removing or including information in accordance with the objectives and purpose of the research.

Inclusion criteria: Thematic relevance: Selection **1**of sources that are relevant to the field or sub-field of interest. For example, for biodiversity analysis, include sources that focus on conservation, ecology or species.

Time period: Define the time frame for data collection. For example, one can only choose sources published in the last 10 years to reflect recent research.

Publication type: Filters the source by publication type, such as scientific journals, conferences, books, reports, etc. Only peer-reviewed journals or scientific publications can be selected.

Language: Only sources written in certain languages that are relevant to the research may be included.

Exclusion criteria:

Industry-irrelevant: Exclude sources that are irrelevant to the topic or address topics outside of the area of interest.

Data quality: Exclude sources that are considered to have incorrect or incomplete data.

Duplicate publications: Remove duplicates or papers that are replicated across multiple sources to avoid inflation or distortion of results.

Non-peer-reviewed publications: Some bibliometric reviews exclude publications that are not peer-reviewed because they may have a different level of scientific credibility.

These inclusion and exclusion criteria are applied to ensure consistency and relevance of the data that are used in bibliometric analysis, thus supporting research objectives and validity of results.

Co-author's analysis

Interactions between scientists in a field of research are examined in the co-author's analysis. It is crucial to reveal how researchers interact with each other, as co-authoring is a formal form of intellectual collaboration between scientists [1]; [12]. Interactions between researchers appropriately include associated attributes of the author, such as affiliated institutions and countries. According to [1], collaboration between researchers has become common practice due to the increasing theoretical and methodological complexity of research. In fact, collaboration between scientists can bring significant improvements in research results. For example, results from multiple research sources can provide multiple perspectives and greater clarity [35]. In this case, a network of scientists working together forms "invisible collages" [14]. The research of these scientists can help create research companies [14]. For example, the analysis may reveal studies conducted by researchers in a particular region, and this data can serve as a basis for supporting and encouraging researchers involved in areas that have been underrepresented. The analysis also allows mapping collaborations over different time periods. This allows researchers to review the trajectory of intellectual development in relation to collaborative networks. In parallel, the analysis provides young researchers with valuable information to reach the level of collaboration with experienced researchers and to understand current research directions.

Bibliometric analysis enrichment toolkit

This section presents additions based on the basic techniques of bibliometric analysis. These additions can be claimed to optimize the performance of analysis techniques used in bibliometric studies. In general, three ways to improve based on network analysis are presented: network metrics, clustering, and visualization.

Network values

Bibliometric analysis evaluation can be improved with network metrics. In particular, research basics such as authors, institutions and nations, which are often not represented in publications or citations, are clarified by network indicators. In bibliometric research, network metrics are often used to improve analyses related to research areas [4]; [5]; [8]; [12] And is therefore an acceptable approach to improving bibliometric reviews. Network values such as degree centrality, centrality between, eigenvector centrality, proximity centrality, and PageRank are given below to provide more clarity:

1. A degree of centrality is defined as the extent to which a constituent element of research is connected to a network. For example, if an author who is part of a network of coauthors collaborated with four different authors, then his degree of centrality would be four. Since it is based on the number of relational ties, this is by far the simplest measure of centrality. The centrality of weighted degree, which can be obtained by multiplying the total number of relational bonds by the strength of each bond, is another type of measure.
2. Closeness centrality refers to the ability of a node to send data efficiently due to its close interaction with other nodes in the network. The sum of the distances to these nodes indicates how simple it is for them to transfer data compared to other nodes in the network.
3. An alternative method of assessing the impact of a publication is PageRank analysis [15]. The method has been modified for use in bibliometry, although it was originally designed to rank web pages based on keywords. In particular, PageRank can be used to assess the prestige of publications that exert influence on a particular field of research by comparing them with other publications with a significant impact, even if they are not highly cited themselves. Therefore, a publication with a high PageRank score is considered "high quality" and is

therefore included among the "essential" publications in the category of highly cited publications. In addition, to identify topics in a research field, PageRank can also be used in the grouping process described in the next section.

Grouping

To enrich bibliometric analysis, clustering is a method that creates thematic or social clusters depending on the type of analysis performed. Observing the development and refinement of network clusters can help understand how a field of research emerges and grows. For example, thematic clusters can highlight significant themes that form the intellectual fabric of research and how they evolve over time through co-citation analysis and bibliographic relationships. There are various grouping techniques available, such as exploratory factor analysis, hierarchical grouping, island algorithm, Louvain method, multidimensional scaling and simple central algorithm, which can be used in a complementary manner [41].

Visualization

Bibliometric analysis is often associated with network visualization software. These programs can range from full GUI applications, such as VOSviewer (developed by van Eck and Waltman in 2010), to customized solutions, such as the Bibliometrix package for the R language (developed by [7]). Other commonly used bibliometric programs include UCINET, Bibexcel, Pajek, Gephi, SciMat, and Sci2. Since most of these network visualizers are free and open source, researchers have the freedom to choose the right solution for their needs. Each program has advantages and disadvantages.

PageRank is determined by the number of citations an article has received from other articles which, in turn, have received many citations, which denotes the prestige of the article. Direct citations of an article are called global references. Citations to an article that are filtered for that domain and come only from the review group are known as local references. Local quotes are usually smaller than global quotes and can never be larger than this, indicating errors in the review group. Comparing global and local citations can help us understand the impact and influence of research by revealing the impact and influence of research on this and other disciplines. The development rate of bibliometric networks is lower compared to that of software such as Gephi and R. Another challenge lies in the flexibility of the networks created. For example, while VOSviewer can generate a network, it cannot join different formats of the same words, while Gephi has this capability. The simultaneous use of bibliometric analysis and network visualization programs is one way to solve this problem. Indeed, this complementary approach is used in many bibliometric studies to overcome software shortcomings and reap its benefits (e.g. [8]; [17]; [40]). Therefore, when selecting bibliometric software for analysis and visualization, it is important to evaluate the characteristics and degree of flexibility of the created network.

4. CONCLUSIONS

This paper illustrated that bibliometric analysis is an essential method in exploring and reviewing extensive areas of specialized research, being useful for both experienced researchers and those at the beginning of the road. The growing popularity of the bibliometric approach is due to the increasing availability of specialized software and databases. Those technological resources facilitate the collection and analysis of significant amounts of scientific research data, including in emerging areas such as big data and artificial intelligence.

Highlighting a comprehensive bibliometric analysis, this paper brought into discussion the bibliometric methodology, various techniques and improvements in bibliometric analysis, outlining a detailed picture of the importance of this tool in specialized research.

However, it is important to point out the limitations involved in bibliometric analysis. Data in scientific databases may contain errors, necessitating the need for rigorous cleaning of such data. Researchers should be cautious in drawing qualitative conclusions, taking into account these possible errors.

It is also crucial to note that bibliometric studies can only provide a short-term perspective on the field of research and should not be used as a basis for ambitious claims about long-term impact. These limitations underscore the need for a critical approach in interpreting the results and conclusions obtained from the bibliometric analysis.

Future research prospects should focus on precisely improving bibliometric methodologies, reducing errors in databases, and applying innovative techniques to obtain more reliable data. Future directions could also explore expanding bibliometric analysis into interdisciplinary and emerging fields, as well as integrating more complex evaluation criteria to assess the impact of long-term research.

Overall, bibliometric analysis is a valuable tool in exploring areas of specialized research, but it is imperative that we carefully confront its limitations and continue to innovate towards a more effective and critical use of this method in research.

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