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Bibliometric analysis of categories of sustainable development

Abstract

Bibliometric analysis is a research method that is used to identify research gaps and the potential paths of empiric exploration of such categories that seemingly have been studied, but which in which enormous scientific and utilitarian capabilities remain undiscovered. Sustainable development is one such category. The purpose of this article is to present the development and evolution of scientific literature on sustainable development, and the research goal is to forecast the developmental directions for this category. Bibliometric analysis was used in the research. Scopus, the international interdisciplinary database, was the data source. Maps of co-occurrence of keywords relating to sustainable development were prepared in VOSviewer ver. 1.6.19.

The results of the research provided new and crucial knowledge about the features of contemporary literature on sustainable development, determined following analysis of the content of selected open access journals that are representative for this field. The chronological aspect of research of the concept of sustainable development was also underlined. This, in the context of management development, resulted in essential conclusions and results pointing to the potential directions of development of the analysed area. The results also identify the key publications and journals for the subject being researched. This is one of the few works which features a comprehensive bibliometric analysis of sustainable development (Díaz-López et al., 2021; Nobanee et al., 2021; Yamaguchi et al., 2023; Zhu & Hua, 2017). The added value of the analyses is the information that was prepared in the form of rankings using bibliometric indicators such as the number of citations, number of articles cited, and the map of co-cited journals.

Keywords: sustainable development, climate change, environmental protection, bibliometric analysis, VOSviewer program

Introduction

In recent years, bibliometric analysis has become widely popular in the science of management and quality, including business studies (Donthu et al., 2021; Khan et al., 2021). This statistical method supports the quantitative analysis of research work and key research areas, and supports prediction of the future research (Yu et al., 2020).

The purpose of bibliometrics is to identify the studied area and pre-identify the research topics that have not been explored yet or have been explored to a minimum extent (Bonilla et al., 2015; Leydesdorff & Vaughan, 2006; Ravikumar et al., 2015). This is the first stage of seeking the scientific research gap and significant grounds for initiating specific scientific actions in the analysed area. Regular bibliometric analyses may serve as an aid in strategic management of the science sector (Podsakoff et al., 2008) and development of the R&D strategy for scientific institutions and enterprises by providing comprehensive knowledge about trends in the development of scientific studies and technologies (Landström et al., 2012; Martínez-López et al., 2018).

For ten or so years, we have seen an animated discussion on the advantages and disadvantages of bibliometric tools and methods from the viewpoint of objectivisation of and more efficient evaluation of researchers, universities, institutes and scien-

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tific journals (Merigó & Yang, 2017). The advantages of bibliometrics include aspects such as research into citability recognized as an objective measure of the quality of a journal and the quality of scientific work, as well as comparison of scientific productivity of a researcher and university (Huchang et al., 2019). Bibliometric analysis helps to track scientific development and demonstrate the share of individual countries in global progress, while the impact factor and immediacy index are the more subtle quantitative evaluation indicators of the scientific status of a journal, which actually reflect the quality of papers published in the journal. The bibliometric approach provides the most comprehensive view of the entire scientific system, since any other study compared to it is fragmentary. A simple yet crucial principle must be remembered here, as mentioned by Ratajewski and Racki many years ago: bibliometric indicators only demonstrate the quantitative relations in scientific literature, and not the scientific value of a publication (Ratajewski & Racki, 1999). Therefore, when this method is used, particular care and prudence is necessary. This method should be used as a preliminary or pilot tool that can be applied to define the level of exploration of a specific scientific category or concept.

The concept of sustainable development has emerged as the answer to the need to limit the human activity that is destructive to the natural resources (Costanza et al., 2016; Saini et al., 2022). It is aimed at preventive elimination or at least mitigation (Liu et al., 2023) of the imbalance between economic growth and social development and between socio-economic development and nature (Qureshi et al., 2017; Weber, 2014). It is man that has for far too long failed to assume responsibility for his actions, thus lowering the quality of their own life and that of other living creatures, as exemplified for example, by diseases caused by the degradation of the environment, various kinds of pollutants, or shrinking of living space (Andersson et al., 2022).

Due to the massive interest in the concept of sustainable development on the part of science and practice, this study identifies directions in which studies in this area could proceed, and is intended to achieve the following goals:

1. Scientific goal: to present the development and evolution of scientific literature on sustainable development.
2. Research goal: to forecast further areas in which categories of sustainable development will change.

This paper consists of three main parts. The first part presents an overview of literature on the subject, which is mainly intended to identify the keywords. Next, bibliometric analysis of the categories was performed, as presented in the second part of the work. This part also describes the research methodology. The third part presents conclusions and limitations of the research conducted.

Sustainable development – overview of literature

Concern for the state of the natural environment is one of the principal reasons for the inception of the idea of sustainable development (Trusina et al., 2021), which was promulgated at the Earth Summit conference organised by the UN in Rio de Janeiro in 1992. During the event, sustainable development was defined as development that ensures fulfilment of social needs with respect for environmental protection, without putting the existence of future generations at risk (Abbas & Sağsan, 2019; Klarin, 2018). The concept of sustainable development is to some extent an answer to the growing belief in the global accountability of societies for local changes in the environment (Zgurovsky, 2007), as well as the alarming nature of the relationship between man and the environment and the consequences thereof (Kopyrin & Vidishcheva, 2021).

Sustainable development is defined as management and shaping of the resources of the natural environment (Emas, 2015; Fukuda-Parr, 2016) and organization of societal life in a way that helps to improve it, while preserving high quality of life and proper use of natural resources, and ensuring development for the new manufacturing process (Dutta et al., 2011; Rabie, 2016). This category should be understood as a constant drive towards the best possible economic result (Dubravská et al., 2020) while respecting the natural environment and societal development (Du Pisani, 2006; Hák et al., 2016). Thus, sustainable development is social and economic development which involves the process of integrating political, social and economic actions with respect for the balance of nature and sustainability of basic natural processes. This is done to guarantee that fundamental needs of societies or citizens of contemporary and future generations are guaranteed (Act of 27 April 2001). Crucially, sustainable development should be viewed as a socially established process of adaptive change with an inherent element of change and innovation (Kemp et al., 2005).

Importantly, sustainable development should foster fulfilment of fundamental human needs and protection and development of the natural environment (Rasoolimanesh et al., 2023) and ensure social self-determination and cultural diversity (Klarin, 2018). Thus, it is an environmental-social-economic category (Kopnina, 2016).

The key assumptions behind sustainable development include liquidation of the unsustainable system of production and consumption, fighting poverty, and protection and development of the natural environment. Economic growth should result in increased social cohesion (such as prevention of discrimination and marginalization, reduction of social stratification) and help to increase the quality of the natural environment (by taking measures including those intended to mitigate the harmful impact of production and consumption on the environment and natural resources) (Robèrt et al., 2002).

It transpires that the concept of sustainable development is analysed only in terms of economic categories as the best idea to overcome the socio-economic and economic crisis. When the concept of sustainable development is explained, it is stressed that economic development takes priority (Buse & Hawkes, 2015), as conveyed in the definition, which reads that “sustainable development (...) is a socially desirable, economically expedient and ecologically desirable economic development strategy”. Given this, sustainable development and its implementation is an issue that requires in-depth consideration.

Also, the essence of sustainable development is the consent to socio-economic development in harmony with respect for the natural environment (Broman & Robèrt, 2017; Landi et al., 2022). Despite this, sustainable development does not and cannot act as a brake for economic development, but it must be an innovative approach to economic development, opposing economic growth in the traditional sense, while maintaining a high level of prosperity (Bond et al., 2001; Gull et al., 2022). Given this, sustainable development should be well-considered and properly planned taking into consideration the contemporary challenges resulting from the notion of sustainable development conceived in this way (Pradhan et al., 2017).

To sum up, sustainable development of the Earth is development that fulfils fundamental needs of all people (Tosun & Leininger, 2017), and which also ensures the protection, preservation and restoration of health and integrity of ecological systems of the Earth (Ianos et al., 2009) without compromising the ability of future generations to meet their own needs and without the risk that the limits of the Earth's endurance are exceeded.

Sustainable development is not a state, but a process. It is a fluid concept that has changed over time and in space (Littig & Grießler, 2005), yet despite being an ambiguous term, it has common elements such as prudent management of natural resources, caution with respect to the principles of environmental protection, and a long-term outlook and compliance with the socio-economic reality (Barbosa et al., 2014; Mensah, 2019). Sustainable development provides an opportunity for reducing degradation of the environment, protection of renewable and non-renewable natural values (Kaltenborn et al., 2020), changes to the consumption model, streamlining production and improvement, and creating an equal level of social well-being today and in the future (Jitmaneroj, 2016; Mio et al., 2020). Highly developed countries have a different understanding of sustainable development than developing countries (Güney, 2017), for which sustainable development is the same as development measured in terms of consumption growth indices.

Global transformation to bring about sustainable development is closely related to threats such as

climate change and environmental protection (Banuri & Opschoor, 2007; Burch et al., 2014; Swart et al., 2003). Prevention of climate change and protection of the natural environment is one of the primary challenges for contemporary society. Climate change resulting directly and indirectly from human activity puts achievement of sustainable development goals at risk (Munasinghe, 2010; Tanner & Allouche, 2011). Well-considered actions to prevent climate change and adverse consequences (adaptation to the climate change) may and should be an integral part of durable and sustainable development and reinforce each other (Robinson et al., 2006). Thus, sustainability represents the need to maintain relevant proportions, development structures and balance between the needs for development and the need to protect the environment (Toukabri & Mohamed Youssef, 2023). The feature of sustainability requires maintaining availability of environmental resources and development *per se* underlines the co-dependence of the economic, ecological and social factors in stimulating long-term economic growth and the role of the ecological conditioning of such growth.

An overview of literature produced a definition of the following keywords that were subjected to bibliometric analysis: sustainable development, climate change, environmental protection¹.

Bibliometric analysis of categories of sustainable development – research methodology

This article presents an overview of literature on sustainable development. The research started with a search for articles in the Scopus database, deemed to be one of the most versatile databases of reviewed journals (Ding, 2020). The Scopus international database contains the majority of relevant scientific papers which also provide built-in analytical tools for creating representative data. What is more, Scopus search results can be exported into the VOSviewer file, a program which was used in this analysis. A search was carried out in the Scopus database for the keywords sustainable development, climate change, environmental protection. The search of the Scopus database was limited to the subject comprising article titles, abstracts and keywords. Then, the results were filtered by language (English) document type (article), and research area (Business, Management and Accounting, Environmental Science, Social Sciences) which produced 27,125 articles. The article title, author names and affiliation, journal name, number, volume, pages, publication date, abstract and cited references to the bibliometric analysis were identified. The search of the Scopus database was limited to the subject comprising article titles, abstracts and keywords. Then, a prepared set of publications relating to the concept of sustainable development was analysed in a specialized program, VOSviewer.

¹ These words were entered into the database in the English language, thus the results obtained were also displayed in English. For the purposes of this publication, these words were translated into Polish.

Selection of publications based on search engines that utilize specific ranking algorithms creates a risk of omission of interesting papers that have been rarely cited but have a large impact potential. Consequently, it is becoming increasingly difficult to obtain a more or less comprehensive view of research in a given field and identify the research gap of interest (Wisniewski et al., 2022). Therefore, the authors applied the technique of visualisation and clustering using VOSviewer (Sanguankaw & Vathanophas, 2019).

A total of 27,125 scientific articles indexed in the Scopus database demonstrates a regular increase in interest in the subject from 2008 to 2022, as presented in Figure 1. Generally, since 2008, there have been signs of the growing popularity of the subject, although the number of publications peaked in 2022 at 5,178 articles. Thus, starting in 2008, the concept of sustainable development has enjoyed increasing interest among researchers. In addition, this trend will continue over the next few years.

Based on such deliberations regarding keywords, a query was formulated to perform a search by titles, keywords and abstracts (Chen et al., 2016) which was entered into the Scopus database in the following form:

TITLE-ABS -KEY
(sustainable AND development, AND climate
AND change, AND environmental AND protection)
AND (LANGUAGE, "English")

Keywords were selected on the basis of analysis of the literature on the subject. Reference articles included papers that addressed the subject of sustainable development in the context of climate change (Grist, 2008; Robinson & Herbert, 2001; Swart et al., 2003).

This stage is crucial, as the results may change if a different query is entered. This selection was made in accordance with the scientific goal of the paper (Wisniewski et al., 2022), which is to present the development and evolution of scientific literature on sustainable development.

Bibliometric analysis of categories of sustainable development – study results

Figure 1 presents the distribution of annual publications and the evolution of the number of articles published. The earliest document found that applied the selected criteria was published in 2008. A regular increase in the number of publications on sustainable development was recorded over subsequent years. This means that since 2018, there has been a considerable increase in the number of these publications, which demonstrates that researchers are particularly interested in the subject of sustainable development.

The next stage of studies of bibliometric data was the analysis of citations for the countries which publish articles on the concept of sustainable development in the Scopus database. The bibliometric analysis demonstrated that English was the main language used in scientific research.

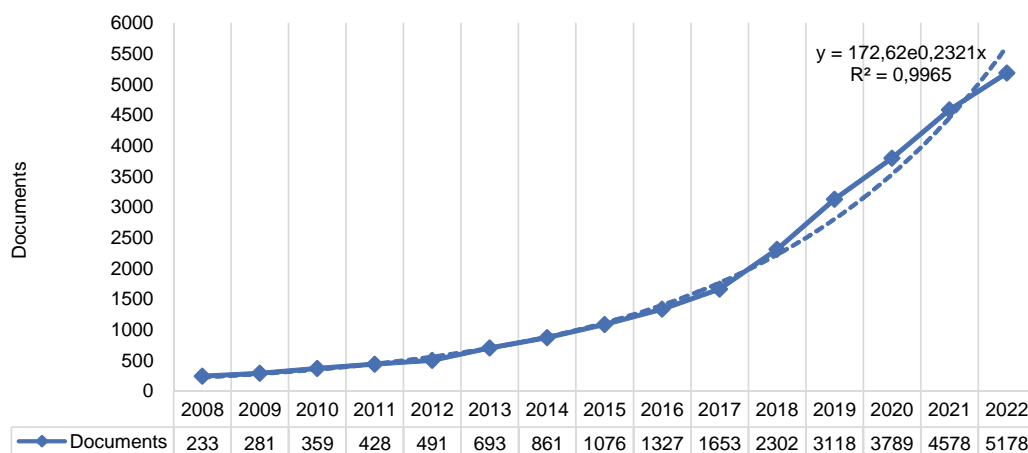
Figure 2 presents the countries with the largest number of papers on sustainable development issued from 1988 to 2021. The analysis of the countries was based on the papers which stated the address and affiliation of at least one author (Abejón et al., 2017).

In terms of the number of articles published, China was first with 5,927 published articles, followed by the United Kingdom with 4,099 published articles, and the United States with 3,442 published articles.

The bibliometric analysis presents the link between keywords (Gaviria-Marin et al., 2019) which create the network identifying the ones that appear more frequently for the studied subject (van Eck & Waltman, 2010), thus facilitating the study of concepts (keywords) and subjects (concepts grouped into clusters). This analysis was conducted in VOSviewer, which generates the visualisation and supports a multi-dimensional data representation (Pico-Saltos et al., 2021), as shown in Figure 3.

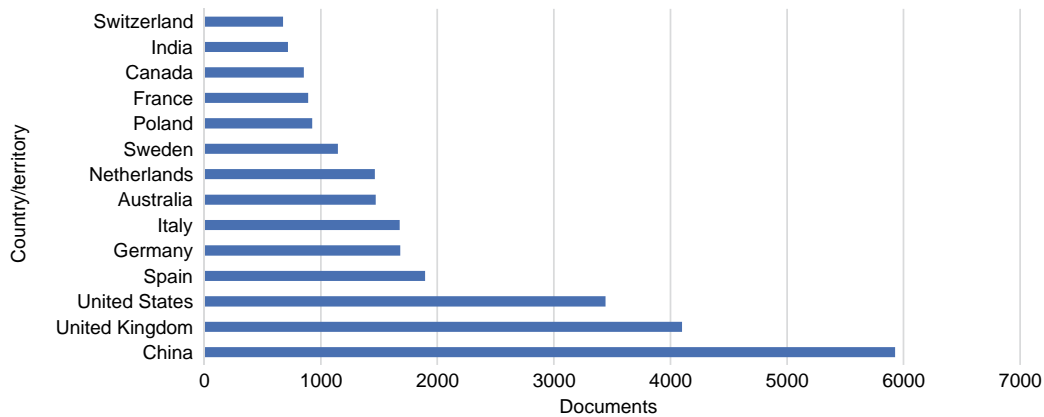
The size of individual nodes represents the number of times items occurred (the higher, the greater the number) and the affinity of items depends on the number of articles in which they were found together

Figure 1
 The number of publications on the concept of sustainable development from 2008 to 2022



Source: authors' own work based on the Scopus database.

Figure 2
Citations from the ten best journals from 1988 to 2021



Source: authors' own work based on the Scopus database.

(Jansen et al., 2022). The differences in cluster sizes are also presented in Figure 3. Figure 4 presents the clusters or the concepts grouped by subject, the size of which may be used to identify the preliminary research gaps.

In accordance with Figure 4:

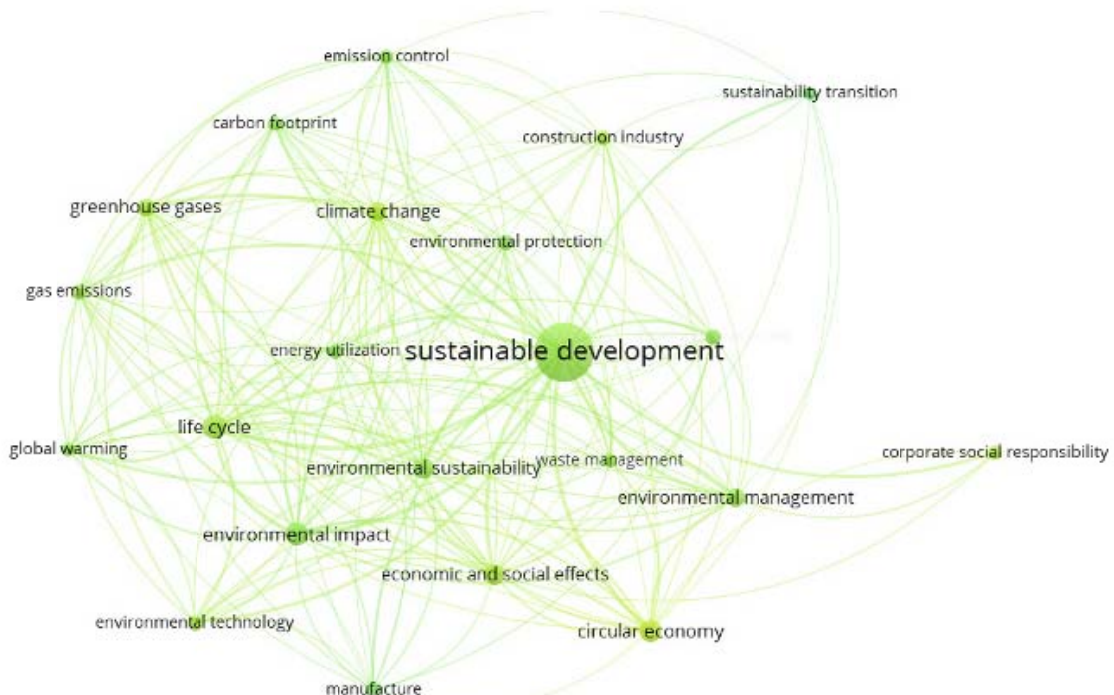
- Cluster 1 (in red) represents a research area which consists of nine nodes and is called “carbon footprint”,
- Cluster 2 (in green) represents a research area which consists of even nodes and is called “sustainable development”, because this is the definition most frequently found (2,000) in this class,

- Cluster 3 (in blue) represents a research area which consists of six nodes and is called “developing countries”, because this is the definition most frequently found (64) in this class.

Table 1 presents the list of keywords shown in Figure 4 in the form of a network (clusters). It also includes the total link strength category, which represents the number of links of a given category with other elements and/or the total power of category links with other analysed elements.

In the detailed approach, these clusters describe keywords presented in Table 2. These are those keywords which the authors of articles on sustainable development entered in their papers.

Figure 3
Network of co-occurrence of keywords

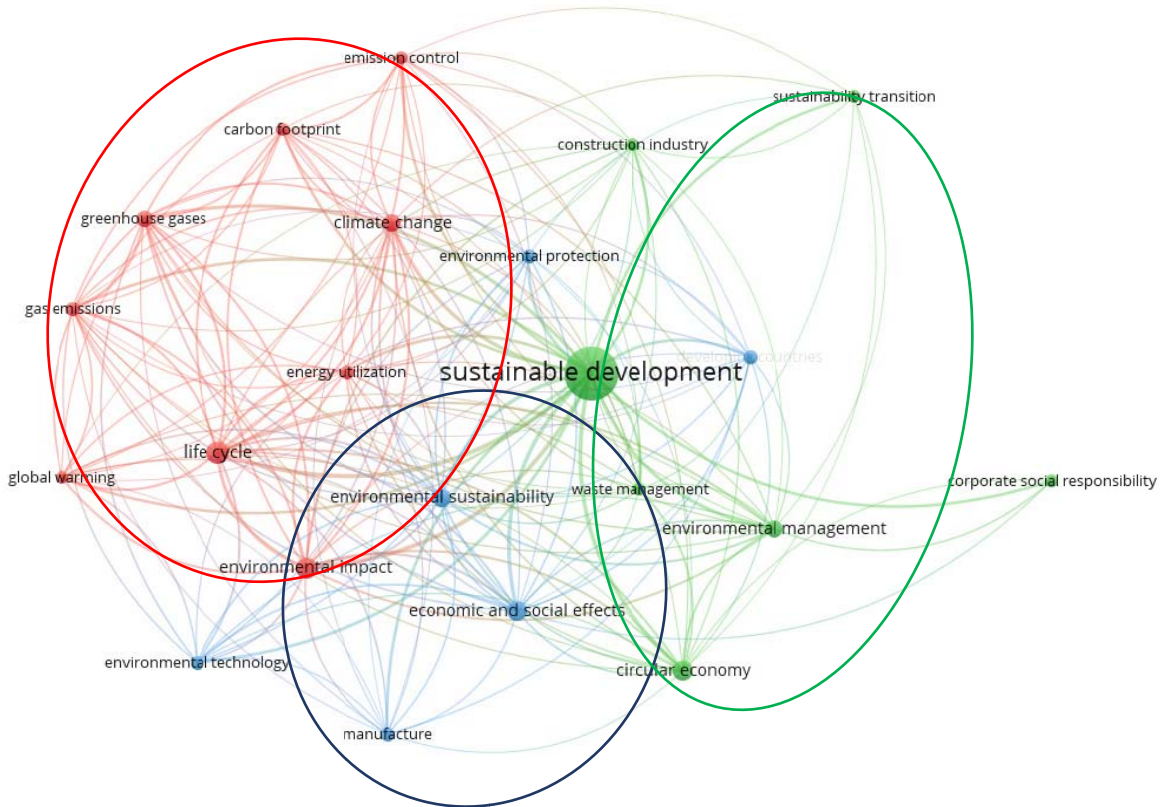


Source: authors' own work based on the Scopus database.

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Figure 4

Network of co-occurrence of keywords relating to sustainable development created in VOSviewer



Source: authors' own work based on the Scopus database.

Table 1
Keywords and their occurrence

No	Keyword	Occurrences	Total Link Strength
1*	sustainable development	2000	1942
2.	life cycle	206	664
3.	impact on the environment	177	548
4.	circular economy	164	347
5.	economic and social effects	151	379
6.	environmental sustainability	139	387
7.	climate change	117	304
8.	environmental management	113	299
9.	greenhouse gases	99	371
10.	environmental technology	72	217
11.	environmental protection	68	153
12.	energy utilization	67	204
13.	developing countries	64	134
14.	gas emissions	63	259
15.	production	61	136
16.	corporate social responsibility	60	82
17.	carbon footprint	59	197
18.	waste management	54	140
19.	emission control	53	162
20.	construction industry	52	117
21.	global warming	52	196
22.	sustainability transition	51	72

Note. * items 1–9 describe cluster 1 elements, items 10–16 – describe cluster 2 elements, while items 17–22 describe cluster 3 elements.

Source: authors' own work based on the Scopus database.

Table 2

Description of clusters in the context of keywords defined by publication authors

Cluster number	Keywords used by authors
Cluster 1	carbon footprint, climate change, emission control, energy utilization, impact on the environment, gas emissions, global warming, greenhouse gases, life cycle (nine elements)
Cluster 2	circular economy, construction industry, corporate social responsibility, environmental management, sustainable development transformation, sustainable development, waste management (seven elements)
Cluster 3	developing countries, economic and social effects, environmental protection, environmental sustainability, environmental technology, manufacture (six elements)

Source: authors' own work based on the Scopus database.

The fundamental indicator used to determine the bibliometric characteristics of the author is the number of citations per publication. Table 3 presents the most frequently cited articles on sustainable development with the number of citations per article.

Table 3

Most frequently cited articles on sustainable development

No	Number of citations	Author/authors
1.	333	Hughes et al., 2019
2.	317	Shahbaz et al., 2019
3.	312	Bai et al., 2020
4.	254	Dubey et al., 2019
5.	247	Kivimaa et al., 2019
6.	240	Roscoe et al., 2019
7.	237	Tura et al., 2019
8.	223	Rosati & Faria, 2019
9.	213	Nižetić et al., 2020
10.	190	Kusi-Sarpong et al., 2019

Source: authors' own work based on the Scopus database.

The scope of citations ranged from 190 for the article ranked 10, to 333 for the leading article. Based on this, it was possible to determine the key moment of development of the analysed category, which was the turn of 2019 and 2020, while the categories most frequently explored in the context of sustainable development were carbon footprint, climate change, emission control, energy utilization, and impact on the environment. This means that the remaining clusters, in particular the third cluster, are essential areas where research gaps in sustainable development should be sought.

In the context of sustainable development, there is an identified research gap regarding sustainability transition, or multi-level transformation (shift, direction) of the economic system and the socio-technological system intended to achieve a low-carbon, resource-efficient and responsible economy. It transpired that this category is practically non-existent in the Polish literature (Daszyńska-Żygadło & Ryszawska, 2015, p. 63).

Conclusion

This article presents pilot research aimed at carrying out a bibliometric analysis of sustainable development category and at identifying research and publication trends. The study was conducted using the Scopus database. The analysis identified thematic areas which are the subject of most publications on sustainable development. Such subjects certainly include areas listed in cluster one. This means that the potential research gaps should be sought in cluster three subjects.

The results of scientific studies were presented on the maps prepared in VOSviewer ver. 1.6.19.

In recent years, there have been studies to measure the level of sustainable development and socio-economic development in the comprehensive approach. This paper also underlined the growth rate in the interest in the concept of sustainable development, which helped to determine the years with the highest growth in publication works in this area, which were 2019 and 2020. There has been rapid change in interest in this category as an area of scientific research, and this has been undoubtedly an essential subject of empirical work, as proven by numerous articles in business and management journals. Therefore, it has become extremely important to determine areas that have been hardly explored or not explored at all.

Bibliometric analysis does not cover in full the issue of identification of research fields (Sikacz, 2017), and this includes with respect to sustainable development reporting. The rapid development of scientific research in multiple fields and the increasing interdisciplinary nature of such research has contributed to the development of the body of scientific knowledge, but has also made it difficult for scientists to track the current status of research. Limited cognitive resources make it impossible to conduct a complete overview of literature, and the selection of publications based on search engines that utilize specific ranking algorithms creates the risk of omission of interesting papers that have been rarely cited but have a large impact potential. Consequently, it is becoming increasingly difficult to obtain a more or less comprehensive view of research in a given field and identify the research gap of interest. In such situations, methods of data exploration and machine learning can be applied, es-

pecially as regards processing and analysis of natural language, including using tools such as VOSviewer.

The main goal of the research was assumed to be to determine the key moments of sustainable development evolution and forecast future directions in which it will develop. This goal was achieved through the bibliometric analysis of the picture of the contemporary literature on sustainable development, which proves researchers' interest in that field. The practical value of the research conducted was the information obtained about the most frequently cited authors, articles and journals. The scientific goal was to present the development and evolution of scientific literature on sustainable development, and this goal was also achieved.

In addition, secondary goals achieved during the work on this paper include: (1) identification of the most frequently cited publications, (2) identification of titles of journals of key importance for the researched area, (3) identification of the most frequently cited author and presentation of co-authorship on the subject of sustainable development.

The bibliometric analysis based on the Scopus database demonstrated the presence of publications on sustainable development. There was a considerable increase in the number of publications in that field during the researched period (2008–2022). The first papers were recorded in 2008–2011, with a rapid increase over subsequent years. This article presents a subjective evaluation of the state of literature on sustainable development. This is pilot research which provides a preliminary picture of the development of the analysed categories.

This work certainly has its limitations, for example it does not analyse Polish publications, and analyses only the Scopus database. This leaves room for further empirical explorations and the use of other keywords.

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