

Definition of Sustainability - Bibliometric Analysis of the Most Highlighted Papers

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Abstract. We live in a world where sustainability is a concept encountered often and discussed a lot in academic literature, taking on a special scope since the 1990s and developing significantly as a notion until now. The definition of sustainability is mostly open to readers, giving them the opportunity to think about it, rethink it, or even interpret it and then redefine it. In the research, it is carried out a review of some definitions from the literature of the term sustainability, then it is carried out a bibliometric analysis in this field over a period of 10 years, from 2013 to 2023, where it is identified the largest research networks in the field formed by groups of authors with a common interest, the most cited works of the period, respectively, the most encountered and cited keywords, in order to emphasise the evolution of the concept from the perspective of several authors who have a common research topic. To carry out the research, it is used the Harzing Publish or Perish software, with which it is extracted information from the Google Scholar database and which it is later used for the network representation using the VOSviewer tool. The largest research network that is obtained is made up of seven authors, also it is carried out a top of the most cited papers, finding the one with a number of 6917 citations at the top and it is noticed that during the years 2013-2018 they most works in the field have been published. The research carried out offers a perspective of the evolution of the concept of sustainability, which can be extended for the purpose of more detailed research.

Keywords: evolution, development, research, VOSviewer, bibliometric analysis

Introduction

Sustainability is a concept of interest these days, debated by many researchers, and with applicability in many fields.

Since 1987, when Brundtland defined sustainability as the “ability of present generations to meet their needs without compromising the ability of future generations to meet their own needs”, it has attracted attention and induced continuous research both on the definition of the concept itself and the way in which it can be applied or quantified. Brundtland's definition left room for interpretation, so many researchers over time have defined the concept depending on the field, but sustainability has the flexibility to be clarified from several perspectives.

In this work, we have carried out a bibliometric analysis of the concept of sustainability, having as a reference the definition of sustainability. Over the years, this concept has been very varied, receiving a fairly significant number of definitions.

This bibliometric analysis helps us to follow the evolution of the concept of sustainability at the global level over a longer period of time and how much attention has been given and is still

being given to this "mode of survival" so that we are protected, not only by the generations present but also by those who will come after us, future generations. It is necessary to realize how important it is both for us and for our descendants to live in balance and to be concerned about what is happening around us.

Through this analysis, we aim to offer a perspective on the stage in which the concept of sustainability is and on the relationships between authors who research the same subject with the aim of identifying the importance of sustainability at the global level and, at the same time, the necessity of its applicability in as many fields as possible, especially in the manufacturing area.

Literature review

Sustainability is a subject of interest in this world of research, being applicable in most fields and being generally represented by the three dimensions of social, economic, and environmental. They define sustainability in a broader sense, being closely linked and often influencing each other.

Carrying out a review of the academic literature, many researchers sought to define this concept, each having their own interpretation of what Brutland stated in 1987, or even redefined sustainability according to new requirements or the field of applicability and we chose some of those definitions.

Leach et al. (2010) define sustainability as the ability to maintain specified qualities of human well-being, social equity, and environmental integrity over indefinite periods of time. In another interpretation, the social and economic dimensions are included, focusing on the reduction of harmful effects on the environment: "[...] sustainability can be understood as the effort to minimise the negative economic, environmental, and social effects of an activity, either by a manufacturing company, a service provider, a government body, etc. (Bengtsson et al., 2011). Sustainability refers to the willingness to grow and improve, which is a challenge for a world with limited resources and a finite scale (White, 2013). Sustainability is about ensuring that we will have natural resources in the future to enable human existence (Feil et al., 2017). Sustainability involves people. When people are able to harmonise all aspects of their lives to achieve their personal purpose without sacrificing the quality of their lives, they achieve human sustainability (Sandra et al., 2017). Martin Geissdoerfer et al. (2017) define sustainability as the systemic and balanced integration of intra- and intergenerational economic, social, and environmental performance. Sustainability opens up the space of diverse expectations about what should be developed and sustained, for how long, and for whose benefit, instead of just setting common goals (Geissdoerfer et al., 2017). An additional approach to the concept of sustainability is through the lens of "longevity," where "the longer a system can be maintained, the more sustainable it is" (Marchese et al, 2018). Sustainability depends on transformational skills in designing transitions and the ability to withstand stress and unforeseen events. Thus, sustainability extends beyond the achievement of ideal goals to the careful examination of the forces and obstacles that allow or prevent the transformation of society (Vogt M., 2019).

Based on these definitions, we can say that sustainability is in our hands, the people's, and it depends on us how much or how little we are sustainable, regardless of the situation or circumstances. Being sustainable means thinking about the future; it also means not to waste but to capitalise, so that no one suffers as a result of your activities.

Methodology

We performed an analysis of the works published in the period 2013–2023, which have in context the definition of sustainability, through the Google Scholar database. So I extracted, with the help of the Harzing Publish or Perish software, all the articles that were published during this period and put the concept of sustainability in context. The selection criteria of the works was based on the keywords sustainability definitions for the period 2013–2023. The search results revealed a number of 989 articles addressing this topic. Thus, thorough research was carried out regarding the approach to the concept using the VOSviewer tool, which has the ability to classify the information extracted from the Google Scholar platform according to the number of citations, respectively, of keywords in the area of sustainability. In addition, we used the VOSviewer tool to highlight the collaboration between authors, the impact of the articles, and other relevant elements such as keywords or countries that were involved in the research.

According to the information in Table 1, extracted from the Google Scholar database using the Harzing Publish or Perish software, the most publications in the field of sustainability were found in the period 2013–2018, with over 100 papers prevailing annually. Since the software has a limited number of selected papers, not all papers from the year 2023 could be displayed; the maximum selected limit is 1000 papers for the time range searched. Performing a separate search for only the year 2023 yielded 992 papers, but with far fewer citations. Therefore, in the initial search, only works with a large number of citations were selected. At the top of the list of published works is the year 2013, which represents 15.57% of the total number of extracted published works, so this year 154 works were published. The years 2014 are also very close, with 149 papers, representing 15.07% of the total, or 2017, in which 150 papers were published, i.e., 15.16% of the total number of 989 papers from 2013–2023. Starting in 2019, a decrease in the number of published and cited works can be observed: 78 works in 2019, representing only 7.89% of the total, so a percentage approximately halved compared to the period of the top years 2013-2018. Therefore, the number of works extracted from the period 2019-2023 is on a descending scale, representing a minimal percentage of the total number of works extracted (Table 1).

Table 1. Top of the number of papers published each year in the period 2013-2023

Year	No. of publication	% of 998
2013	154	15,57 %
2014	149	15,07 %
2015	125	12,63 %
2016	125	12,63 %
2017	150	15,16 %
2018	122	12, 33 %
2019	78	7,89 %
2020	54	5, 46 %
2021	16	1,61 %
2022	13	1, 31 %
2023	3	0, 30 %
Total	989	100 %

Source : own research using Harzing Publish or Perish.

The results obtained and found in Table 1 are graphically represented in Figure 1.

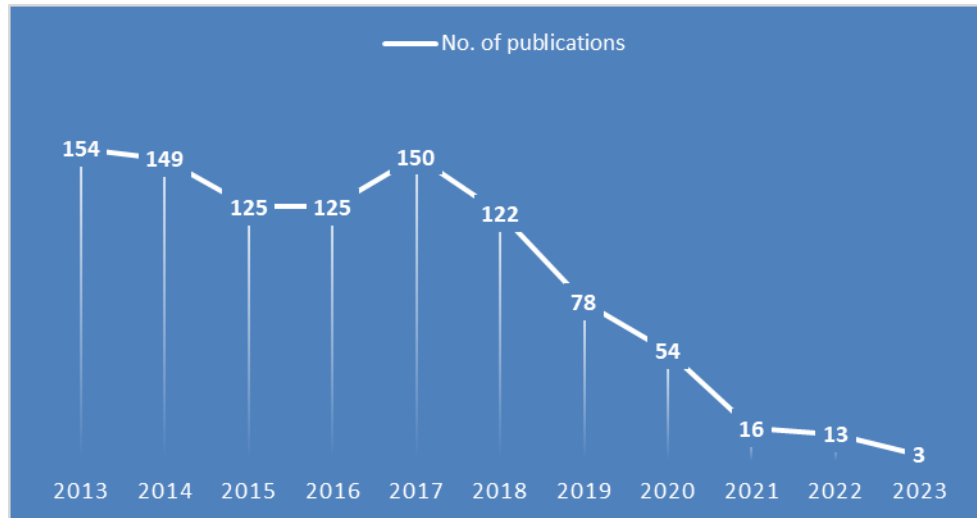


Figure 1. A graphic representation of the number of publications from the period 2013–2023

Source: own research.

Results and discussions

With the help of the VOSviewer tool, we performed the bibliometric analysis of the works published in the period 2013–2023 in the Google Scholar database, extracted from here using the Harzing Publish or Perish software, which identified 989 works. We thus created a network regarding the analysis of the co-authors and one regarding the analysis of the keywords used in the selected research field, sustainability, or more precisely, definitions of sustainability.

1. *Bibliometric analysis of co-atorship*

Carrying out the analysis of the co-authors, we can observe not only their interest but also their collaboration in the same direction, approaching the same research topic. With the VOSviewer tool, we can create a network where each node represents the number of published articles. After the analysis, a number of 8 clusters resulted, and each cluster is marked by a different color (Figure 2).

The largest network consists of 7 authors: David Tilman (University of Minnesota, USA), Ghang Xu (Washington State University), H. Charles J. Godfray (University of Oxford, UK), Jianguo Liu (Michigan State University), Lan Yang (University of Ireland), Tara Garnett (University of Oxford, UK), and Vanessa Hull (University of Florida).

The second cluster consists of six authors: JingJing Wang (Beijing Jiaotong University, China), Thomas Dietz (University of Münster, Germany), Tianyu Li (Centre for Quantitative Economics of Jilin University, Changchun, China), Xi Chen (Zhejiang University, China), Yuanli Li (Chongqing University, China), and Yingfeng Zhang (Northwestern Polytechnical University, Xi'an, China).

The third cluster consists of five authors: Behzad Esmaeilian (Western New England University, USA), Baicun Wang (Zhejiang University, China), Kristin C. Lewis (Volpe National Transportation Systems Centre, Cambridge, MA, United States), Yi Wang (Sun Yat-sen University), and Ying Zheng (Fujian Jiangxia University, China).

The fourth cluster consists of three authors: Ana Beatriz Lopes de Sousa Jabbour (Montpellier Business School, France), Charbel Jose Chiappetta Jabbour (Montpellier Business School, France), and Devika Kannan (University of Southern Denmark).

The fifth cluster consists of three authors: Joseph Sarkis (Worcester Polytechnic Institute, USA), Mahtab Kouhizadeh (Worcester Polytechnic Institute, USA), and Sara Saberi (Worcester Polytechnic Institute, USA). Cluster 6 consists of 3 authors: Ahmad Jafarian (University Business School, Tehran, Iran), Kannan Govindan (University of Southern Denmark), and Roohollah Khodaverdi (University Business School, Tehran, Iran). Cluster 7 consists of 3 authors: Philip Beske (University of Kassel, Witzenhausen, Germany), Stefan Gold (University of Kassel, Germany), and Stefan Seuring (University of Kassel, Germany). Cluster 8 consists of 3 authors: Jun Zhang (Capital University of Economics and Business, Beijing, China), Qingmin Liu (Department of Economics, Columbia University, New York, U.S.A.), and Yuanqiang Ye (Fudan University, Shanghai, China).

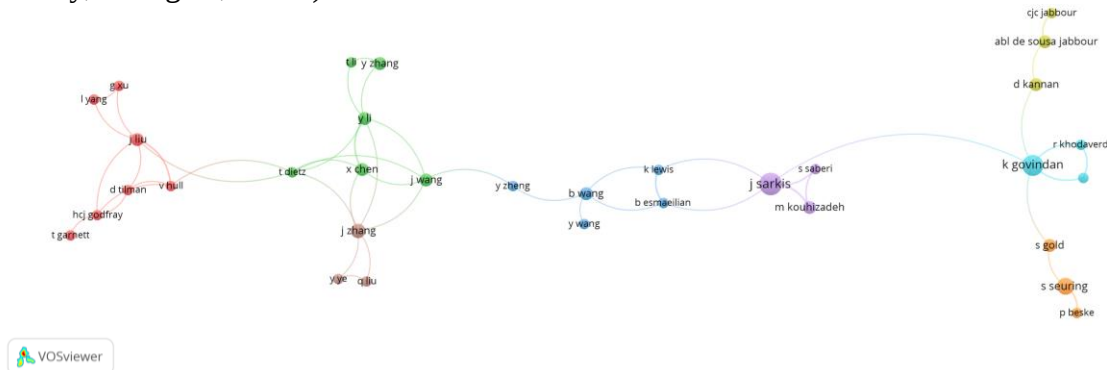


Figure 2. Co-authorship analysis network

Source: VOSviewer.

2. Bibliometric analysis of keywords

Carrying out a keyword analysis has a role in observing the links between the published works, which are grouped according to the common research objective. The VOSviewer tool was also used for this analysis, through which we obtained a network of keywords based on their frequency in the published works from the examined database (Figure 3).

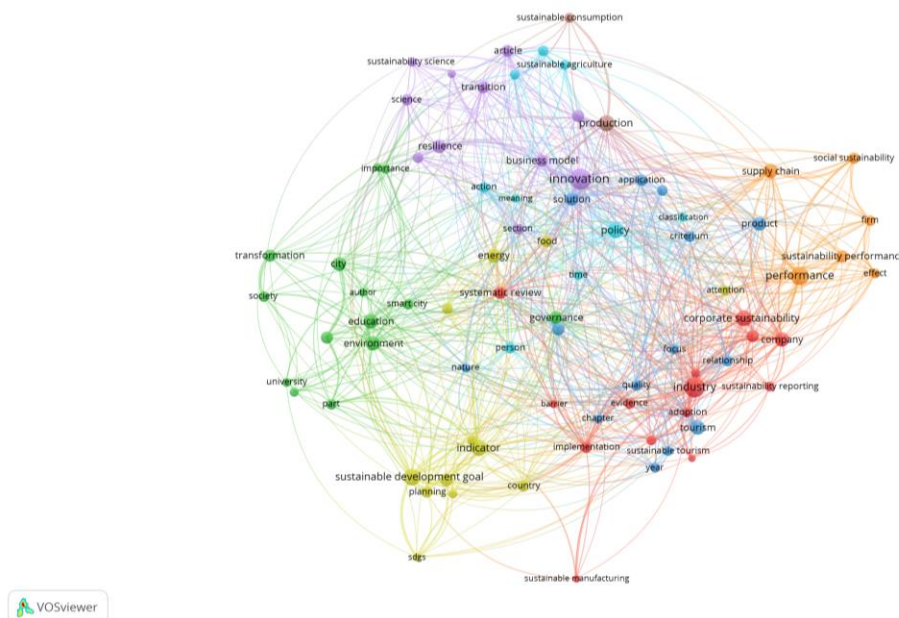


Figure 3. Keyword Analysis Network

Source: VOSviewer.

No.	Keywords	Number of occurrences
1.	Innovation	71
2.	Industry	63
3.	Performance	53
4.	Sustainable development goal	45
5.	Corporate sustainability	40
6.	Indicator	40
7.	Production	38

These keywords were especially used from mid-2015 to 2017, with the most citations (Figure 4).



Using Harzing Publish or Perish software, which extracted 989 works from the Google Scholar database based on the keywords "sustainability definition," we were able to make a ranking

of the most cited works that approach the identified topic. The result of the classification of the most cited works is presented in Table 3.

Table 3. Top 10 most cited papers

No.	Author	Title	Publication	Year	Citation
1.	Martin Geissdoerfer et al.	''The Circular Economy – A new sustainability paradigm?''	Journal of Cleaner Production https://doi.org/10.1016/j.jclepro.2016.12.048	2017	6917
2.	Julian Kirchherr et al.	''Conceptualizing the circular economy: An analysis of 114 definitions''	Resources, Conservation and Recycling https://doi.org/10.1016/j.resconrec.2017.09.005	2017	6656
3.	Wee-Jun Ong et al.	''Graphitic Carbon Nitride (g-C ₃ N ₄)-Based Photocatalysts for Artificial Photosynthesis and Environmental Remediation: Are We a Step Closer To Achieving Sustainability?''	Chemical reviews https://pubs.acs.org/doi/10.1021/acs.chemrev.6b00075	2016	5733
4.	Martin Mowforth , Ian Munt	''Tourism and Sustainability''	Taylorfrancis.com https://doi.org/10.4324/9781315795348	2015	5356
5.	Juho Hamari et al.	''The sharing economy: Why people participate in collaborative consumption''	Journal of the Association for Information Science and Technology https://doi.org/10.1002/asi.23552	2016	4956
6.	N.M.P. Bocken et al.	''A literature and practice review to develop sustainable business model archetypes''	Journal of Cleaner Production https://doi.org/10.1016/j.jclepro.2013.11.039	2014	4618
7.	Vito Albino et al.	''Smart Cities: Definitions, Dimensions, Performance, and Initiatives''	Journal of Urban Technology https://doi.org/10.1080/10630732.2014.942092	2015	4431
8.	Jouni Korhonen et al.	''Circular Economy: The Concept and its Limitations''	Ecological Economics https://doi.org/10.1016/j.ecolecon.2017.06.041	2018	3602
9.	Alan Murray et al.	''The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context''	Journal of Business Ethics https://doi.org/10.1007/s10551-015-2693-2	2017	3274
10.	F.Boons and F. Lüdeke-Freund	''Business models for sustainable innovation: state-of-the-art and steps towards a research agenda''	Journal of Cleaner Production https://doi.org/10.1016/j.jclepro.2012.07.007	2013	3047

Source : own research using Harzing Publish or Perish.

The most frequently referenced study, by Martin Geissdoerfer et al. (2017), examined the two concepts – circular economy and sustainability – which have distinct but related meanings. The purpose of this paper is to elucidate the parallels and divergences between the two ideas. The writers uncovered many correlations between the two concepts based on the literature, highlighting both their similarities and contrasts, with the aid of tools like bibliometric analysis and the snow Bulgarian approach. Sustainability is the systemic and balanced integration of economic, social, and environmental performance within and across generations, according to Martin Geissdoerfer

et al. (2017). Rather than merely establishing shared objectives, sustainability creates room for varying expectations about what should be developed and sustained, for how long, and for whose benefit. On the other side, by slowing, stopping, and limiting material and energy flows, the circular economy is a regenerative system that reduces resource use and waste, emissions, and energy leakage. This can be accomplished through a variety of techniques, including design, maintenance, repair, reuse, remanufacturing, refurbishment, and recycling (Geissdoerfer et al., 2017).

Julian Kirchherr et al. (2017) analyse the concept of circular economy in their paper, citing over 100 definitions from the academic literature, with the aim of making it better understood but also to emphasise the importance of its implementation. Comparing the circular economy and sustainability, the authors claim that few definitions have common aspects, with the circular economy concept mainly referring to economic prosperity, then to environmental quality, and too little to social aspects (Kirchherr et al, 2017).

Wee-Jun Ong et al. (2016) study the effects of graphitic carbon nitride (g-C₃N₄) on the environment. In recent years, this research topic has attracted the attention of researchers in different fields because it is a metal-free and visible light-sensitive photocatalyst in the arena of solar energy conversion and environmental remediation. The authors perform a significant review of recent advances in graphitic carbon nitride nanocomposite development and construction. The purpose of this review is to open a new section of research and help the next generations of graphitic carbon nitride photocatalysts demonstrate good performance by utilising their outstanding structural, electronic, and optical properties without causing environmental harm (Wee-Jun Ong et al., 2016).

Juho Hamari et al. (2016) study "collaborative consumption" and why people do it, using data collected from a survey that was recorded on a website that analyses and questions people who participate in such activities. The results show that sustainability, activity satisfaction, and economic gains are the reasons why participation in collaborative consumption is of interest. Additionally, research findings indicate that sustainability is not directly related to participation unless it is related to a positive feeling towards the activity. This indicates that sustainability may be the only significant factor for those who consider green consumption important (Hamari et al., 2016).

N.M.P. Bocken et al. (2014) conducted a literature review on what a sustainable business means. It starts with a definition based on the academic literature of the sustainable business model as well as its importance, then proposes a classification of the archetypes of sustainable business models. These include: maximising material and energy efficiency; "waste" can be turned into value; replacing natural processes and renewable resources; providing functionality instead of properties; Adopt a leadership position; reorient business towards the environment and society (Bocken et al., 2014).

In their paper, Vito Albino et al. (2014) discuss the definition of a "smart city." The authors find a connection between this and the notion of sustainability. The purpose of their study is to clarify the meaning of the word "smart" in relation to cities by examining the literature, relevant studies, and official documents of international organizations. They examine a variety of metrics of urban intelligence to demonstrate that it is essential to establish a consensus on what a smart city means, its characteristics, and how it performs compared to traditional cities (Albino et al., 2014).

In an effort to define the circular economy from the standpoints of sustainable development and the science of sustainability, J. Korhonen et al. (2018) conducted a critical analysis of the idea from the standpoint of environmental sustainability. They also identified a number of obstacles that the circular economy must overcome in order to contribute to global sustainability. The difficulties

they identify in their research can also function as research questions and goals for scientists who wish to advance sustainable development by using the circular economy (Kohonen, 2018).

In their paper, Alan Murray et al. (2017) examine the conceptualizations and origins of the circular economy, emphasising its importance and examining its origins in economics and ecology. It also analyses how the circular economy has been implemented in the political and business spheres. According to their study, while the circular economy focuses on repairing processes and material cycles to help create more sustainable business models, it also encapsulates conflicts and limitations, finding that the social dimension is absent. Consequently, they propose a redefinition of the circular economy as “an economic model in which planning, resources, procurement, production, and reprocessing are designed and managed, both as a process and as a result, to maximise the functioning of the ecosystem and human well-being.”(Murray et al., 2017).

By using a business model viewpoint, Frank Boons and Florian Lüdeke-Freund (2013) aim to promote research on sustainable innovation. They contend that studies on sustainable innovation have not taken into account the ways in which businesses might combine a value proposition with a financial model to provide sustainable innovations to the market. Since there is currently a lack of a comprehensive conceptual definition of sustainable business models in the literature, the authors present examples of normative requirements that business models should adhere to in order to foster sustainable innovation. Lastly, they formulate several guiding questions and offer a rough outline of a research agenda (Boons and Lüdeke-Freund, 2013).

Conclusion

In conclusion, sustainability is a concept debated in the literature, but it does not have a single definition; there are a multitude of definitions of sustainability, which leaves room for interpretation. In our research, we wanted to follow the logical course of the evolution of academic writings in this area of sustainability to highlight the importance of the concept and the need to implement it in everyday life. We highlighted the trends already existing in the specialised literature and the main authors who studied and published in this sphere; moreover, we highlighted those who were the most read and the most cited. There was a peak period in terms of the number of publications in this field. Based on the information provided by Google Scholar, we noticed that during the period 2013–2018 there were the most publications, so it was a period of interest for researchers in the world of academia, with 2013 being the top year in which the most papers were published, 154 papers, representing 15.57% of the total number of papers in the field of sustainability published in the period 2013–2023. Using VOSviewer, we can see that the largest research network in the field consists of 7 authors: David Tilman (University of Minnesota, USA), Ghang Xu (Washington State University), H. Charles J. Godfray (University of Oxford, Great Britain), Jianguo Liu (Michigan State University), Lan Yang (University of Ireland), Tara Garnett (University of Oxford, UK), and Vanessa Hull (University of Florida). Also, following the analysis, a number of 1482 keywords were identified with at least 10 citations for each word, and the first 3 most cited are innovation (71 citations), industry (61 occurrences), and performance (53 citations). On the other hand, classifying the most cited works from the period 2013–2023, the work of Martin Geissdoerfer et al. with the title "Circular Economy: A New Paradigm of Sustainability?" published in 2017 in the *Journal of Cleaner Production* is the most cited paper with 6917 citations. Future research in this area of sustainability can focus on the need for implementation as well as the circumstances, depending on the field of applicability and conditions. Our study can be extended to more detailed information over narrower periods of time with more detailed information.

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