Trends and Patterns of Sustainable Technology: A Bibliometric Analysis of Economies.

Trilok Pratap Singh¹*, Utkal Khandelwal¹
Institute of Business Management, GLA University, Mathura, India

*trilok.pratap@glau.ac.in

Abstract. Engineering creates efficient products, systems, and structures. However, suppose the products, procedures, or facilities are not easy to find the most efficient solutions to current issues. In that case, engineering efficiency is risky because the wrong thing could be engineered successfully and potentially worsens. The question is how sustainable technology (ST) can contribute. Statistical information was collected from the repository of Elsevier Scopus. The research request consisted of all publications with the terms 'sustainable technology' in their name, description, and keywords. The study was conducted from January 2010 to June 2019. The subject is under pressure; numerous joint publications are available; articles by various writers from European and Asian countries dominate the number of papers, with Finland and India as the leading economies.

Keywords: Bibliometric analysis, Sustainable technology, Sustainable production, Protection, Innovation, Transformation; Environment.

1. Introduction

The word "technology" may be used to define the collection of techniques, knowledge, methods, and processes used in the manufacture of goods or services or the achievement of objectives such as research. Technology may be knowledge of integrating resources to produce the required goods and services, solving challenges, meeting requirements or fulfilling needs, including technological techniques, skills, procedures, equipment, tools, and raw materials, etc., or maybe incorporated into machines, computers, devices and manufacturing facilities that individuals may operate without knowledge of the job.

Sustainable technology is the biggest challenge we face today. This brings together several global concerns of pollution and environmental destruction in which we live; deprivation and hunger, climate change, mineral, and organic depletion; ecological devastation; and regional inequality [1]. The different definitions of sustainability often clash, creating dilemmas for people trying to contribute to sustainable growth. Technologies have been influential in generating the challenges we face, but they will also play a significant role in their resolution [2]. Sustainable technologies are, instead of a social mission. However, technology is deeply rooted in our culture; otherwise, society will inevitably crumble [3].
The results of a technology depend on how it is viewed and used in a social context, how it influences or even changes that context, how it interacts with technical processes and their physical background, the timeframe of the study, and how much use is made [4]. The term 'sustainable technologies' coined during the Brundtland Commission underscored the interlinking of various social issues. This was a crucial step in building a consensus forum for global action [5].

The era of green technology is growing, with an innovative digital transformation. However, the combination of both has rarely been an option before [6]. Emerging technology and creativity have been combined with exponential growth over the last few years. That said, the biggest problem on the market today is finding a balance between these two strategies. Global digitization offers an enormous opportunity to achieve sustainability in technology [7].

Overall, the concept is characterized as a set of ecologically sustainable, stable factors and principles related to long-term social and economic growth prospects. Such networks use a wide range of new technologies. Every digital business wants to make a difference, technologically speaking, and is now opting for sustainable growth [2]. On the other hand, there is a great need to think about the future of the earth and humanity, as far as the eye can see. Climate change, over-consumption of non-renewable natural resources, loss of biodiversity, widespread deforestation, extreme natural disasters, high carbon dioxide, low air quality, and water quality are real challenges that cannot be tackled own. So sustainable technology is helping the companies a lot [8].

All countries are involved in sustainable development programs and are taking practical steps to fulfill the Paris Agreement's obligations. Productive use of natural resources, financial mobilization, the transition from fossil fuels to perpetual energy, mitigation of climate change threats, supply chain development, cross-industry transformation, including IT, the balance between urban and rural economies, adoption of natural solutions, vulnerable groups and protected areas, minimization Perhaps the owners of world-leading companies have a responsibility to deliver and automate innovative digital technologies. Forward-looking companies have taken steps to become clean and green [9].

2. Description of Bibliometric

Bibliometrics complements the qualitative impact analysis steps, such as peer review, funding, patent numbers, and awards. This bibliometric analysis approach can be used quantitatively or qualitatively to address several humanities and science issues [10]. For example, bibliometrics may study literature over time in terms of material, data use, theme representation, or development. Such work also uses indexes such as Scopus or the Science Web. Over the past two decades, bibliometrics has become a popular policy tool for science and research. Many research areas use bibliometric methods for three purposes: to extend their field of operation, measure the influence of a research group, or determine the results of a specific study [11].

3. Definition of Bibliometric

The OECD glossary on statistical terminology describes bibliometric analysis as follows: 'Book, dissertation, or another statistical publication study, to calculate the 'performance' of research teams, organizations and nations, define national or international networks and map the growth of new (multi-disciplinary) fields of science and technology. The thesis concerns the quantity and strength of the research results of a single institution. It helps measure impact or effectiveness as a measuring device. This is used as a numerical control tool to measure operating levels over time [12]-[13].

4. Components of Bibliometrics

Bibliometric research, usually financed by routine grants [14]-[15]. The bibliometric components mentioned above-included texts, newspaper articles, and documents as part of the series and journals'
bibliometric analysis. The main criteria for the bibliometric metrics, (1) are the calculation of what they intend to measure and (2) the equal reproduction of the degree of output. The findings of research should be reproducible under the same conditions. As [14] points out, "only the reliability and precision of all experimental instruments, procedures and processes can guarantee the reproduction of the findings."

4.1 Bibliometric Mapping

Bibliometric mapping is a systematic approach to the bibliometric measurement of various scientific articles [16]. This work allows specific bibliometric graphs to be used. Theoretical theories and bibliometric networks (used for quantitative analysis) have been developed to analyze the co-authorship. The software framework stands for similarity visualization at www.vosviewer.com, VOS-viewer, Leiden University, Netherlands [16]. The VOS software provides and displays bibliometric templates. Networks that include, for example, newspapers, national writers, associations, individual articles, and other structures. We can develop systems using authors, co-authors, co-writers, or bibliographers. VOS-viewer also includes quantitative document extraction features for research literature, in particular abstract titles and articles [17].

5. Purpose of the study

This study aims to provide an overview of current trends in sustainable technology research. To evaluate bibliometric techniques and literature, this research paper reviewed the sustainable research papers included in the Scopus Index over the period 2010-2019. Bibliometric analysis is a study that uses analytical and quantitative methods to investigate the essence of the distribution of journal papers on a specific subject over time [10]. This paper uses bibliometric techniques to demonstrate and act as patterns in the academic and technical analysis of new technologies and inform marketers of successful decision-making.

5.1 This research work is aimed at:

1) Review of the scattering, including the date of publication, authors' countries, articles, reviews and quotation numbers of papers on sustainable technologies;
2) Testing the relationship between quotation and co-citation on sustainable technologies.

This article is divided into four parts. A summary of this work is provided in the first chapter. The second part of this study includes bibliometry methods. The findings of this study are explained. Finally, with weaknesses and suggestions for future studies, we will conclude the investigation.

6. Methodology and Data Information

The paper, reviewing research papers and abstracts, identified relevant, sustainable technologies publications. To achieve this objective, this study considers sustainable technologies research papers in Scopus Index journals to be reliable database sources for ten years (2010–2019). We have chosen 2010-2019 (10 years) as the research period since the initial sustainable technologies work was published only in the essential promotional journals during that time. Information for this paper has been obtained from the Elsevier Scopus database. Work was carried out on 6 August 2020 and included 1095 documents from 2010 to 2019. This research request consisted of all papers with their names, descriptions, or keywords, with the words "sustainable technologies." Each registration document consisted of the year of publication, the date of reading, the author's names, the source and keyword definitions, the description, and the references. It includes 1857 papers from this study. To limit the study's scope, this review looked at only 1095 pieces in the journal article. It omitted 762 papers, conference abstracts, reviews, and programming surveys to inspect the ongoing development of sustainable technologies research through a record of 1095 journals. This research seeks to clarify the examples and effect of sustainable technologies by analyzing two learning structures: the 1095 published papers and 18,573 references. To explore this
subject, the research relies on the survey of 1095 bibliographically recognized documents. Also, 18,573 records were collected from this study.

7. Results

7.1 Classification of the Publication Year

Sustainable technology, mainly distributed online. Figure 1 shows the sequential movement of sustainably distributed technology papers. The Internet and social media platforms are blooming to enhance the impact of sustainable technologies. Nevertheless, the number of articles published in 2019 increased from 58 to 196. Increasing the number of documents on this subject was a growing interest among scientists in sustainable technology. This shows that scientists and researchers are still optimistic that academia will consider sustainable technology theory and work properly.

Table 1: Year Wise Publications on Sustainable Technology

| Year Wise Publications | No. of Publications |
|------------------------|---------------------|
| 2019                   | 196                 |
| 2018                   | 163                 |
| 2017                   | 147                 |
| 2016                   | 122                 |
| 2015                   | 109                 |
| 2014                   | 78                  |
| 2013                   | 80                  |
| 2012                   | 73                  |
| 2011                   | 69                  |
| 2010                   | 58                  |

7.2 Affiliation Wise Publication

Table 2 shows the distribution of 1095 Sustainable Development Studies by scholars. From 2009 to 2019, research institutes focused on international collaborations, producing the most sustainable development publications. These percentage are: Chinese Academy of Sciences (1.83%), Ministry of Education China (1.55%), Universiteit Gent (1 %), Cheongju University (0.91%), Universidade de Sao Paulo - USP (0.82%), McGill University (0.73%), Nanyang Technological University (0.73%), Delft University of Technology (0.73%), Curtin University (0.73%), Wageningen University & Research (0.64%).

Table 2: Affiliation Wise Publications on Sustainable Technology

| Affiliation                                | Publications | Percentage |
|--------------------------------------------|--------------|------------|
| Chinese Academy of Sciences                | 20           | 1.83       |
| Ministry of Education China                | 17           | 1.55       |
| Universiteit Gent                          | 11           | 1.00       |
| Cheongju University                       | 10           | 0.91       |
| Universidade de Sao Paulo - USP           | 9            | 0.82       |
| McGill University                         | 8            | 0.73       |
| Nanyang Technological University          | 8            | 0.73       |
| Delft University of Technology            | 8            | 0.73       |
Table 3 indicates the allocation of the 1095 sustainable technology papers by researchers’ nations. Sustainable technology study has ten main influential countries: United State (15.89%), China (11.69%), India (11.51%), United Kingdom (7.40%), Italy (5.66%), Brazil (5.39%), Germany (5.21%), Spain (4.84%), Soth Korea (4.47%), Canada (4.20%), etc.

Table 3: Country Wise Publication

| Country             | Publications | Percentage |
|---------------------|--------------|------------|
| United States       | 174          | 15.89      |
| China               | 128          | 11.69      |
| India               | 126          | 11.51      |
| United Kingdom      | 81           | 7.40       |
| Italy               | 62           | 5.66       |
| Brazil              | 59           | 5.39       |
| Germany             | 57           | 5.21       |
| Spain               | 53           | 4.84       |
| South Korea         | 49           | 4.47       |
| Canada              | 46           | 4.20       |
Table 3 shows the distribution of publications on sustainable development published by all researchers in different disciplines between 2009 and 2019. Analyzes, based on disciplinary associations, show that the largest number of publications on sustainable development publishers in environmental science (20 percent) and engineering (13 percent) were published between 2009 and 2019.
7.5 Classification of Sustainable technology papers by Journals

The first 1095 papers were published by scholars from different fields in 342 journals covering sustainable development studies. Table 4 shows that many famous and well-known articles published in research papers on sustainability Sustainable technology are widely available in other journals (see Table 3). One hundred seventy-eight scientific papers have been published in the top 15 journals (21.33 percent).

| Journal                                             | Publications |
|-----------------------------------------------------|--------------|
| Journal Of Cleaner Production                       | 51           |
| Sustainability Switzerland                          | 29           |
| Renewable And Sustainable Energy Reviews            | 21           |
| ACS Sustainable Chemistry And Engineering           | 13           |
| Desalination And Water Treatment                    | 12           |
| Science Of The Total Environment                    | 11           |
| Journal Of Environmental Management                 | 10           |
| Bioresource Technology                              | 9            |
| Chemosphere                                         | 8            |
| Environmental Science And Technology                | 8            |
| Chemical Engineering Journal                        | 7            |
| Energies                                            | 7            |
| Energy                                              | 7            |
| Green Chemistry                                     | 7            |
| Technological Forecasting And Social Change         | 7            |
| Waste Management                                    | 7            |

Fig.4: Journal Wise Publications on Sustainable Technology
7.6 Distribution of Sustainable technology publications by Author

Table 5 shows that several prominent scholars have written papers on sustainability studies. Sustainable technology has inspired several well-known authors to publish their papers in many journals (Table 5). Researchers from a variety of backgrounds are working toward sustainable growth. Table 5 shows the comments made by the authors on sustainable technologies. Their contribution is as follows: Jun, S (0.91%), Park, S. (0.64%), Ren, J. (0.55%), Jang, D. (0.37%), Olukanni, D.O. (0.37%), Ozaki, R. (0.37%), Schettini, E. (0.37%), Shaw, I. (0.438%), Vox, G. (0.37%), Xian, M. (0.37%).

Table 5: Author Wise Number of Publication

| Author Name   | No. of Publications | Percentage |
|---------------|---------------------|------------|
| Jun, S.       | 10                  | 0.91%      |
| Park, S.      | 7                   | 0.64%      |
| Ren, J.       | 6                   | 0.55%      |
| Jang, D.      | 4                   | 0.37%      |
| Olukanni, D.O.| 4                   | 0.37%      |
| Ozaki, R.     | 4                   | 0.37%      |
| Schettini, E. | 4                   | 0.37%      |
| Shaw, I.      | 4                   | 0.37%      |
| Vox, G.       | 4                   | 0.37%      |
| Xian, M.      | 4                   | 0.37%      |

7.7 Sustainable technology cited by report

Quota rates indicate the impact on academics and other fields of sustainable technologies. Table 6 lists articles on sustainable technology, widely cited in other newspapers. Lists articles on sustainable technology research, ‘articles,’ in particular Gao M.-R., Xu Y.-F., Jiang J., Yu S.-H.
Table 6: Author Wise (Cited By) Publication

| Authors                        | Title                                                                                           | Year | Cited by |
|-------------------------------|-------------------------------------------------------------------------------------------------|------|----------|
| Gao M.-R., Xu Y.-F., Jiang J., Yu S.-H. | Nanostructured metal chalcogenides: Synthesis, modification, and applications in energy conversion and storage devices | 2013 | 942      |
| Li X., Yu J., Jaroniec M.       | Hierarchical photocatalysts                                                                    | 2016 | 842      |
| Chung T.-S., Zhang S., Wang K.Y., Su J., Ling M.M. | Forward osmosis processes: Yesterday, today and tomorrow                                        | 2012 | 434      |
| Zhu Y.P., Guo C., Zheng Y., Qiao S.-Z. | Surface and Interface Engineering of Noble-Metal-Free Electrocatalysts for Efficient Energy Conversion Processes | 2017 | 412      |
| De Gisi S., Lofrano G., Grassi M., Notarnicola M. | Characteristics and adsorption capacities of low-cost sorbents for wastewater treatment: A review | 2016 | 400      |
| Sheldon R.A., Woodley J.M.     | Role of Biocatalysis in Sustainable Chemistry                                                  | 2018 | 344      |
| Eslamimanesh A., Mohammadi A.H., Richon D., Naidoo P., Ramjugernath D. | Application of gas hydrate formation in separation processes: A review of experimental studies | 2012 | 343      |
| Wen J., Li X., Liu W., Fang Y., Xie J., Xu Y. | Photocatalysis fundamentals and surface modification of TiO2 nanomaterials                      | 2015 | 313      |
| Garcia G., Aparicio S., Ullah R., Atilhan M. | Deep eutectic solvents: Physicochemical properties and gas separation applications               | 2015 | 313      |
| Pusavc F., Krajnik P., Kopac J. | Transitioning to sustainable production - Part I: application on machining technologies        | 2010 | 305      |

7.8 Literatures cited by sustainable technology papers

Sustainable technology is being developed and used to conserve the environment and natural resources. Sustainable technologies cannot be overlooked as part of the renewable energy sector of the environmental technology movement. We have reached a point where we need to pause and reflect on the rising value of sustainable technology and why society needs it. With many arguments about the importance of sustainable technology, volumes could be published and discussed. If sustainable technology is becoming more important in business or at home, things need to be done quickly. There is no need for rocket scientists to say that society needs to do something about healthy ecosystems and conserve energy resources. Sustainability will only help us overcome the difficult situation we face today. Before things get worse, we should consider the value of sustainable technology to solve this problem. The literature level reported in 1095 sustainable technology documents, as stated in Table 6. Such papers provided information for sustainable technology studies. The 15 most cited articles referred to above discussed the theories most commonly used in the sustainable technologies system, the idea common to the different funded studies, and the methods used to perform the experimental experiment (data collision) and the technical references used. The study looked at the following theories. Sustainability is widely used...
in a variety of definitions. Therefore, sustainability should be opposed as a non-scientific concept, and great efforts should be made to describe sustainable technology thoroughly and appropriately. Sustainability can be used as a term articulated (and used) in many ways, depending on the stakeholders, priorities, and audiences [16]. There are joint 'sustainable development' articulations, such as 'pollution-free' or 'creating local jobs' or 'being green.' For example, sustainable material is a substance that is already a more concrete subject of research and requires further clarity for material scientists. Still, for a material scientist to study, material preparation that does not contain any organo chlorine compounds is a reasonably concrete articulation. Such minimal expression is often equivalent to 'sustainable' technologists and scientists in the academic community [20].

![Fig. 6: Keyword on sustainable technologies (created with VOS-viewer)](image)

8. Conclusion

This research demonstrates critical trends in the bibliometric analysis of sustainable technology publications. It concludes that this issue is trend setting, and little study by Latin American countries should be studied. Work is a bibliometric analysis. The Scopus database has been checked, and no useful data material has been found in other databases. While Scopus is one of the world's largest deposits, it indeed does not contain all publications on sustainable science. Scopus is one of the most widely used and accepted science repositories [18]. The bibliometric analysis also makes use of quantitative techniques. It isn't easy to understand the purpose of the publications [19].

Technology is often globalized in today's world, and competition within a single product is still confined to many large corporations. It has a great responsibility for professional designers. In the short and long term, their systems can significantly affect the different facets of our societies [16]. Sustainable development is our biggest challenge. It involves a range of global issues — pollution and deterioration of the environment in which we live; deprivation and hunger; climate change; mineral and organic degradation; environmental destruction; and regional inequity. Have all these problems been solved forever and at once? It is not our intention to add yet another summary to the hundreds already mentioned. We are inspired by the vagueness of the concept of sustainable development, as it underlines the link between the many issues facing the world [17]. Global challenges are all overlapping public domain concerns without a precise definition of sustainable development [20]. Sustainable technology has several applications. The key objective of sustainable technology is to meet human needs in ways that do not impact or deplete natural resources. The aim is to meet current demands without compromise. You have
come to the right place to learn more about sustainable technology priorities. The focus is on the production of goods that are fully recoverable or recycled [21]. Changing production patterns and use make it one of the main objectives of sustainable technologies to reduce waste and emissions. Alternative solutions need to be put in place to prevent further harm to health and the environment. Faster adoption will enhance our atmosphere and protect the planet virtually. Explore sustainable technology, create healthy living conditions, increase renewable energy, and minimize waste [22].

Fig. 7: Basic Functionalities of Sustainable Technologies

Technologies have been instrumental in the development, but they will also be a critical factor in addressing the challenges we face. Explain that sustainable growth is not a technological goal. Instead, sustainable development is the function of society [8]. However, technology is fundamentally embedded in our culture; civilization will crumble immediately. Comparatively, technological advances can be seen faster than lifestyle improvements needed to address the issues we face [22]. Numerous studies of the social and environmental impacts of new technology on society suggest that the effects of technology depend not only on the nature of technology as such but in particular on how technology is perceived and used in a social context; how it affects or even transforms the context [23].

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