

Patterns Trends in Socio-Environmental Sustainability Practices in Leather Industry: A Bibliometric Analysis

Pankaj Kumar Tyagi

Leather and Footwear Technology Section, University Polytechnic,
Aligarh Muslim University, Aligarh-202002, India
tyagipankajamu@gmail.com

SheebaJilani

Department of Chemical Engineering, ZHCET,
Aligarh Muslim University, Aligarh-202002, India
sheeba_jilani@yahoo.co.in

Faisal Talib

Department of Mechanical Engineering, ZHCET,
Aligarh Muslim University, Aligarh-202002, India
ftalib77@gmail.com

Abstract

Sustainability has now linked as the foundation of any development. Economical sustainability has been a thrust for corporates since long but Environmental Sustainability was mostly neglected upto 20th century whereas Social Sustainability is still categories as less explored dimension. The objective of this paper is to underst the growing importance evolution of social environmental dimensions of sustainability in literature specifically related to leather sector. A bibliometric analysis was carried out to achieve the above objective. Scopus database was searched by using a large number of keywords in the title abstract fields. The resulted 542 articles were scanned after removing the duplicity, articles in languages other than English those got published after the year 2000, 349 articles were finally selected. A descriptive analysis of these articles were conducted, based on the significant contributions of influential authors, organizations, countries, publication sources, titles keywords etc., using the different open softwares like Mendeley, VOS-viewer etc. Our findings shows that in the leather sector, in our selected dimensions of sustainability, researchers' interest grew after 2012 before which the publications in these areas remained only in single digit per year. India is the most contributing country in leather sector, followed by the United State of America Italy. Another interesting observation was that around 10% of these documents were published in the Proceedings of 34th IULTCS Congress held at Chennai, India in the year 2017 with a theme "science technology for sustainability of leather". Journal of Cleaner Production is the second most contributing resource followed by the Journal of the American leather chemists association, together these 3 resources contributed more than 20% of the selected documents. Also social dimension of sustainability was probably neglected by researchers in leather sector as only in 6 documents keyword "social aspects" appeared only in one article "social sustainability" keyword was stated. Our researched have certain limitations, as we restricted our searched to SCOPUS data base only future researchers may explore other databases too. This study will contribute in understing the growing role of social environmental dimensions of sustainability for the policy makers/managers/researchers in the leather sector.

Keywords

Leather, Bibliometric Analysis, Sustainability, Social Sustainability, Environmental Sustainability.

1. Introduction

Sustainability is a buzz word in the literature. Every year, thous of articles are published that deals with this aspect in one way or the other after the introduction of the concept of sustainable development in 1992. The term sustainability is still a highly dispersed diverse topic even after this large volume of publications. Driven by social

changes, environmental deterioration accompanying public interest, sustainability is becoming a key topic among academics, regulators, businesses (Büyüközkan and Karabulut, 2018). The concept of sustainability has various perspectives, such as environmental protection, ecosystem services, economic considerations, social acceptance, license to operate externalities, besides many other aspects (Bartelmus, 2010; Figge and Hahn, 2004). Three main aspects, sustainability accounting, assessment reporting processes are the major concern in sustainability management. The aspect of accounting is closely related with what information to collect for which purpose by defining suitable indicators measuring them, which requires robust conceptual models, such as indicator sets while the aspect of assessment is about giving a meaning to the collected qualitative quantitative data by means of analytical integration techniques (Büyüközkan and Karabulut, 2018). Sustainability practices are imperfect, hence there is a need to analyze their construction, evolution deployment (González et al., 2021). The scientific efforts are focused to enhance economic environmental aspects a lack of effort relating the social sphere is resulted in literature Furstenau et al. (2020). Sustainability principles need to be integrated with sustainable manufacturing practices research (Al-Subaie et al. 2021; Bhatt et al. 2020; Gani et al. 2020; James et al. 2022).

The leather industry is one of the oldest largest industries that occupy a place of prominence in the global economy (Ashebre 2014). This industry generally uses hides skins (outer covering of animals) as raw materials, which are the by-products of meat meat products industry. In fact, tanning is the largest industry in the world based on a by-product (Alaoui et al. 2012). Typically, the hides/skins of cattle, goat sheep are used for mass leather making which generally represent the 5% to 15 % of the total market value of the animal (Ramachrana, L. Alagumurthia 2013). The leather sector comprises tanneries (where hide skins are transformed into leather) manufacturing units (where leather footwear, garments outerwear, assorted leather goods are manufactured). Leather sector has an important role in many countries' economy but resulting pollution from this sector is considered as a source of severe environmental degradation too, resulting which this sector is going through a drastic phase change due to strict environmental regulations at global level. A need is felt to revamp different processing methods for the sustainability of leather processing industries. The stakeholders have a difference of opinion in explaining the meaning of sustainability in this sector. Non-Government Organizations (NGOs) have more focus on environmental social sustainability whereas chemical companies are more concerned with economic sustainability but the consumers have a divided thought as some focused more on the social sustainability while some placed durability as top priority (Choudhary 2017).

The phrase sustainable manufacturing is sometimes used carelessly to describe the actions related to characterizing reducing the environmental impacts of manufacturing. The most admissible definition of sustainable manufacturing was given by U.S. department of commerce as "the creation of manufactured products that use processes that minimize negative environmental impacts, conserve energy natural resources, are safe for employees, communities, consumers are economically sound" (Moldavska and Welo 2017). Sustainable production is one of the Sustainable Development Goals (SDG) set by UN in 2015, which defines manufacturing as one of the measures toward sustainable development. While manufacturing has negative impact on the environment, it also creates jobs has a positive contribution to the population's needs for food, shelter, healthcare, as well needs for comfort decent level of life. Also, the manufacturing sector is important for sustainable development of the global society since it helps addressing global challenges such as needs for renewable energy sources, green buildings, etc. Many researchers (Molamohamadi Zohreh Ismail Napsiah 2013; Rosen and Kishawy 2012) have discussed the relation between sustainability manufacturing. Two sub-categories have been defined: manufacturing for sustainability sustainability of manufacturing (Moldavska and Welo 2017).

Manufacturing subsystems coexist alongside human, ecological, natural subsystems leather manufacturing is not an exception to it. Therefore, sustainable manufacturing is a philosophy that cannot be considered independent of broader environmental socioeconomic systems (Dornfeld 2013). Sustainability, however, implies a great deal more than the simple act of analyzing modifying the environmental performance of manufacturing processes systems (Paul et al. 2014).

Bibliometric methods or "analysis" are now firmly established as scientific specialties are an integral part of research evaluation methodology especially within the scientific applied fields (Ellegaard and Wallin 2015). A reason for scholars to conduct a bibliometric analysis is to identify the knowledge base in a specific topic, to examine its research front to map out produce networking structures of the scientific community interested in the topic (Aria and Cuccurullo 2017). Keeping the above in view, a bibliometric analysis was performed on the social

environmental sustainability practices/methods/indicators in leather sector to understand the trends patterns of sustainability practices in this sector.

2. Research methodology

This paper aims to introduce the inclinations of research papers in the domain of social environmental sustainability practices in leather sector. The presented research methodology consists of two consecutive steps. At first, it explained how the papers are identified as the data collection approach, later how these papers are analyzed.

2.1. Data collection approach

Data collection usually starts by selecting the database for the input data. Following the earlier researchers (El Baz and Iddik 2022; Fahimnia et al. 2015; Tseng et al. 2019), our sources are the bibliographic records from Scopus database, which has been considered reliable in these prior works, also Scopus is the largest database of scientific peer-review literature hosting more than 22,000 titles high-impact scientific studies from international publishers (Elsevier.Com). To query the database, we selected the appropriate search terms. To collect these papers, we used number of combination of keywords as mentioned in Table 1 searched in title abstract fields of the papers. After collecting data, the filtration of results is adopted as Scopus is a large database that covers thousands of journals, which necessitate filtering the results: only papers written in English with some relevance in titles were selected in the marked list exported in the Bibtex file format (Table 1).

Table 1. Searched outcomes

Searched Key Words	No. of Papers
(TITLE-ABS-KEY (environ* sust* pract*) TITLE-ABS-KEY (leather))	95
(TITLE-ABS-KEY (environ* sust* meth*) TITLE-ABS-KEY (leather))	209
(TITLE-ABS-KEY (environ* sust* indi*) TITLE-ABS-KEY (leather))	160
(TITLE-ABS-KEY (social* sust* pract*) TITLE-ABS-KEY (leather))	28
(TITLE-ABS-KEY (social* sust* meth*) TITLE-ABS-KEY (leather))	22
(TITLE-ABS-KEY (social* sust* indi*) TITLE-ABS-KEY (leather))	28

The resulted 542 articles of the search outcomes were scanned, after removing the duplicity articles in languages other than English, 349 articles were finally selected for this study.

2.2 Data analysis

The bibliometric analysis is made following the researcher (Ellegaard and Wallin 2015). The bibliometric software allows performing all-inclusive quantitative research in Bibliometrics Scientometrics (Aria and Cuccurullo 2017). The software tackles used in our work are accessible for free that can be used by anybody to decide current inclinations gaps in the available literature databases. The advantage of using free access tools such as Mendeley VOSviewer is that it allows for the clustering of publications without advanced computer skills or profound knowledge of clustering techniques (El Baz and Iddik 2022).

3. Results

This Section presents the obtained results from the bibliometric analysis segmented them into various sections. A descriptive analysis was made covering dominant authors, foremost journals, leading organizations most popular words used in titles keywords, a detailed co-citation analysis.

3.1 Descriptive Analysis

This descriptive analysis objects to discuss authors, their affiliations countries, the sources of documents, as well as the documents, their contents bibliographies. Primary objective of this work is to perform an extensive review of the entire discipline. To do so, we needed to include all documents type (Table 2) extracted with the keywords search on whole document that can provide us with several important scientific contributions.

Table 2. Typology of published work

Typology	Number of documents	%
Journal Articles	211	60
Conference Papers	92	26
Reviews	33	10
Book Chapters	11	03
Books	01	Traces
Editorial/ Letters/ Short Surveys etc.	01	Traces
Total	349	100

Table 3. Scientific Evolution over the year in the searched domain

Year	Number of documents
2002	1
2003	2
2004	2
2005	5
2006	4
2007	3
2008	2
2009	3
2010	6
2011	8
2012	13
2013	10
2014	15
2015	28
2016	20
2017	49
2018	26
2019	41
2020	41
2021	49
2022	21

After 2012, the interest for Social environmental sustainability in leather sector within research domain increased (Figure 1). As up to 2011 the number of publications remained in single digit, whereas from 2012 onwards publications increased to double digits (Table 3).

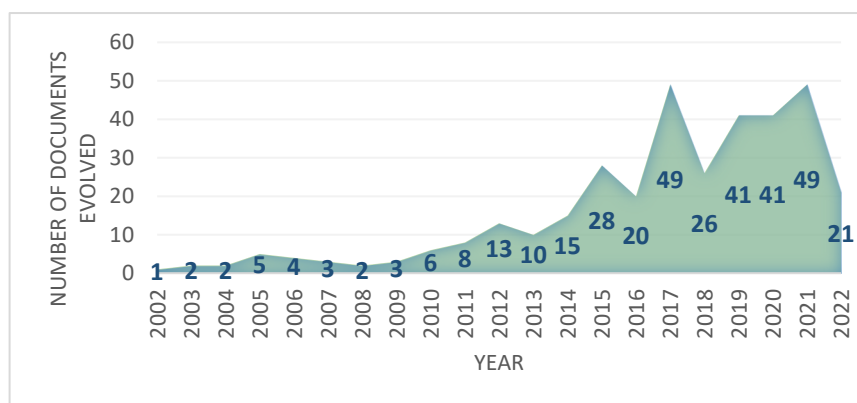


Figure 1. Annual scientific publications in the domain from the year 2000 onwards

3.1.1 Researcher's Influence

These 349 analyzed articles were written by a total number of 1061 researchers, which is almost triple in number of published articles. 40 articles were written by single authors. 11 authors have more than 6 publications. Rao. J. R. is the most contributing author with 8 publications followed by Zhang Y. with 7 publications (Figure 2). Moktadir M.A. is the most cited author with 314 citations from his 6 contributed documents.

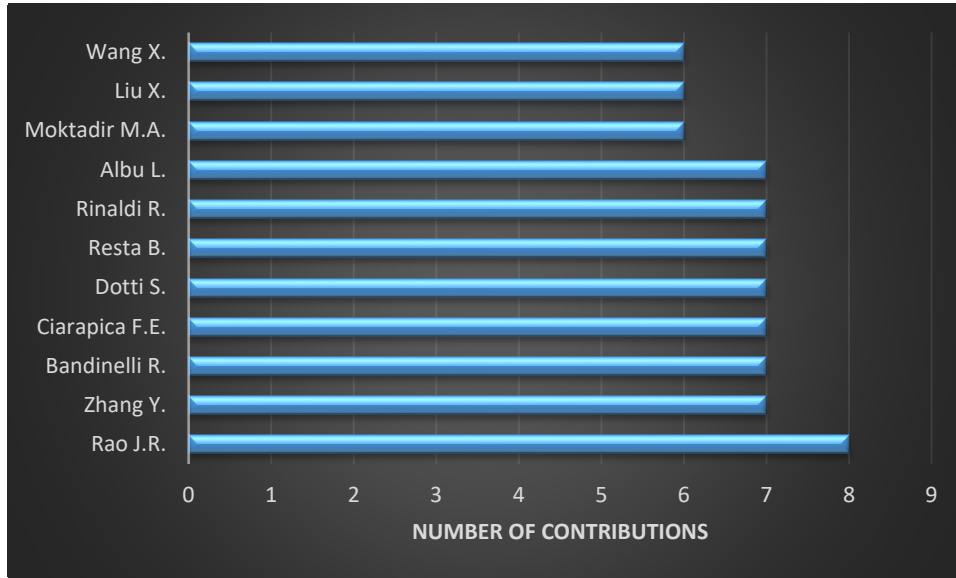


Figure 2. Most contributing author from the year 2001 onwards

3.1.2 Affiliation Analysis

Affiliation analysis shows that these researchers of above documents belong to 691 organizations, out of these 08 organizations have more than 3 contributions. National engineering laboratory for clean technology of leather manufacture, Sichuan University, Chengdu, China is the most contributing organization with 5 articles while Department of industrial production engineering, Bangladesh University of engineering technology, Dhaka, Bangladesh contributed 4 articles (Figure 3) but with a higher citation of 238 in comparison of 63 of Sichuan University.

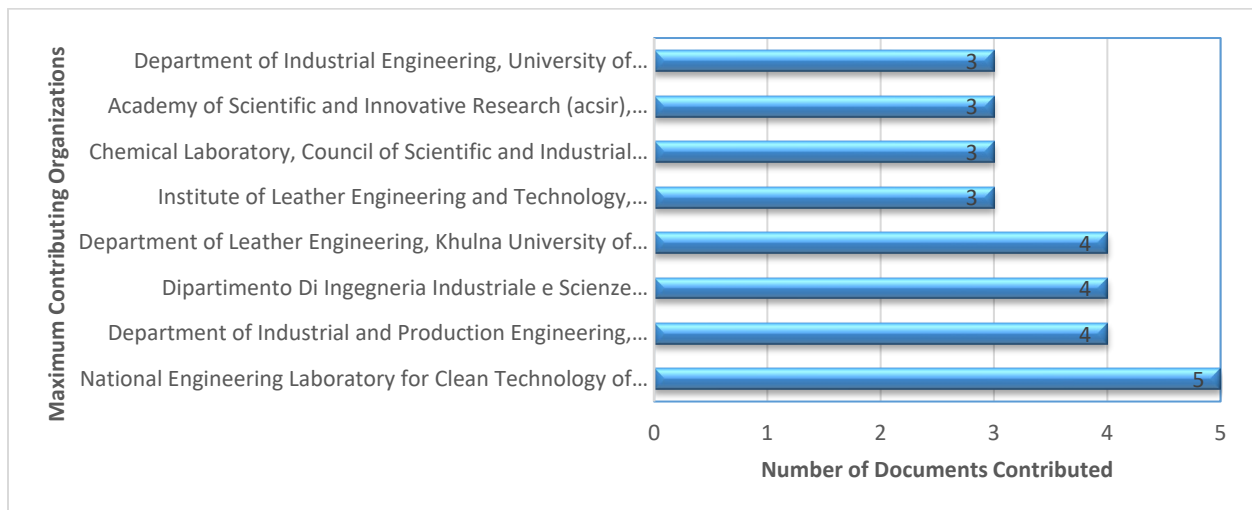


Figure 3. Most relevant affiliations from the year 2001 onwards

Also these researchers belongs to 55 countries, 12 countries have more than 10 publications while 5 have more than 20 publications each (Figure 4) also these 12 countries have contributed more than 90% of the published work in the selected domain in the leather sector. India is the most contributing country with 100 articles followed by China Italy with 47 39 documents respectively.

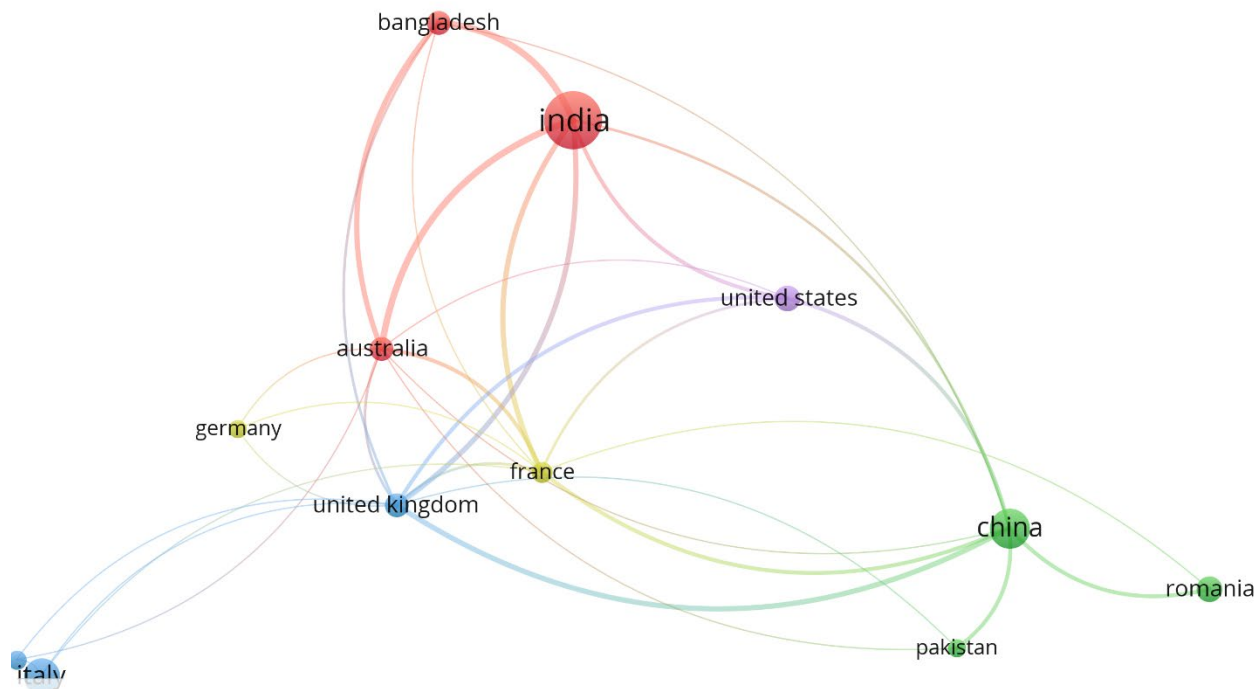


Figure 4. Most contributing countries from the year 2001 onwards

3.1.3 Sources Relevancy

These selected 349 documents were published in 202 sources, out of which 12 sources have published 5 or more articles (Table 4). 31 documents out of the selected 349 documents got published in the “Proceedings of the 34th IULTCS Congress: Science Technology for Sustainability of Leather”. Journal of Cleaner Production ranked 2nd with a publication of 25 articles followed by the Journal of the American leather chemist’s association (JALCA) with 16 publications. These top 3 relevant sources published more than 20% of the selected documents.

Table 4. Top twelve leading sources in the searched domain

Source	Documents	Citations
Proceedings of the 34th IULTCS Congress: Science Technology for Sustainability of Leather	31	1
Journal of Cleaner Production	25	941
Journal of The American Leather Chemists Association	16	77
Environmental Science Pollution Research	7	96
35th IULTCS Congress 2019: "Benign By Design" Leather - The Future through Science Technology	6	0
ACS Sustainable Chemistry Engineering	6	121
Proceedings of the Summer School Francesco turco	6	3
XXXIII IULTCS Congress	6	4
ICAMS Proceedings of the International Conference on Advanced Materials Systems	5	0
Journal of Environmental Management	5	55

Leather Footwear Journal	5	8
Waste Management	5	186

3.1.4. Highly Cited Articles

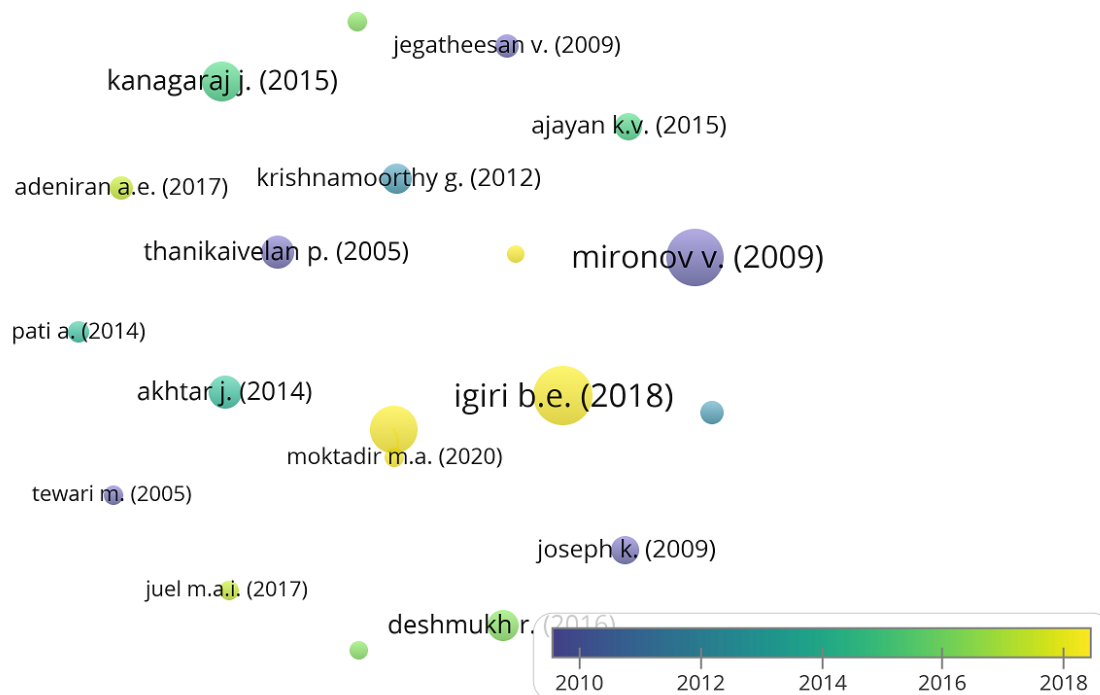


Figure 5. Citation Clustering of most cited documents

The analysis of the 349 selected documents shows that 20 of these documents have 50 or more citations (Figure 5), while 7 articles have 100 or more citations (Table 5). Document written by Igiri et al. (2018) with a title “Toxicity Bioremediation of Heavy Metals Contaminated Ecosystem from Tannery Wastewater: A Review” is the most cited document with 242 citations followed by Mironov et al. (2009) with a title “Biofabrication: A 21st century manufacturing paradigm” with 232 citations article written by Moktadir et al. (2018) with a title “Drivers to sustainable manufacturing practices circular economy: A perspective of leather industries in Bangladesh” with 182 citations.

Table 5. Top most cited documents in the domain

Paper	Source	Total Citations	TC/year
Igiri et al.(2018)	Journal of Toxicology	242	80
Mironov et al.(2009)	Biofabrication	232	19
Moktadir et al.(2018)	Journal of Cleaner Production	182	60
Kanagaraj et al.(2015)	Journal of Cleaner Production	146	24
Thanikaivelan et al.(2005)	Critical Reviews in Environmental Science Technology	115	7
Akhtar et al.(2013)	Applied Microbiology Biotechnology	112	16
Deshmukh et al.(2016)	Indian Journal of Microbiology	105	21

3.1.5 Statistic of Keywords

The statistics of keywords answers about the important words used in the documents. 3681 keywords were used in these articles out of which 17 keywords were used in 20 or more articles (Figure 6) 04 keywords were used in 50 or

more articles. Leather is the most occurred keyword with 163 occurrences followed by sustainable development, tanning, leather industry, chromium with 131, 75, 61, 48 occurrences respectively. Sustainability environmental sustainability remained the 8th, 12th most occurred keywords respectively. Based on the keywords reflection in the literature in the domain of leather sector, we could infer that social dimension was probably neglected as among the above selected articles the key word “Social Aspect” occurred only in 6 articles with 140th place in the list. On the other h in the authors keyword list social sustainability keyword occurred only once out of 1096 keywords used.

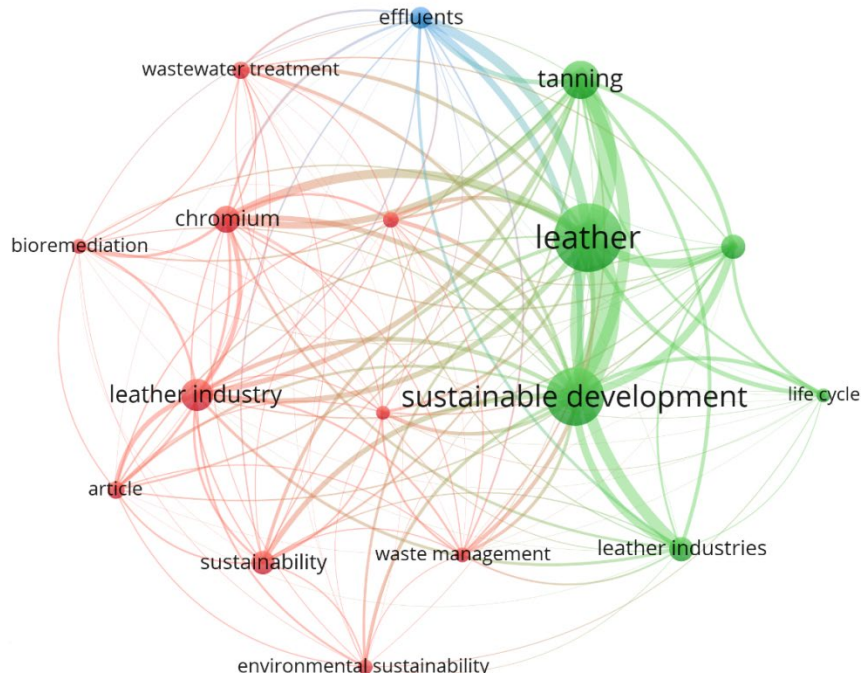


Figure 6. High occurrence keywords

3.1.6 Intellect Inputs: Co-citation Analysis

Through the references cited in these 349 collected articles, the intellect input is presented herewith in three different clusters based on the most cited references, most cited sources, most cited authors. Figure 7, shows the 5 most cited references among the 14123 references those were cited more than 5 times in the collected documents. Further our collected 349 articles cited 6506 sources, out of which 14 sources were cited in more than 50 collected documents (Figure 8). Journal of cleaner production was the most cited source by our selected documents with 727 citations followed by Journal of The American Leather Chemists Association Journal of Hazardous Materials with 254 139 citations respectively. Also, these 349 articles cited 26655 authors, among them 19 authors were cited in more than 50 documents as presented in Figure 9. Rao, J. R. was the most referred author in these selected articles with 182 referrals followed by Nair, B. U. Ramasami, T. with 137 112 referrals respectively.

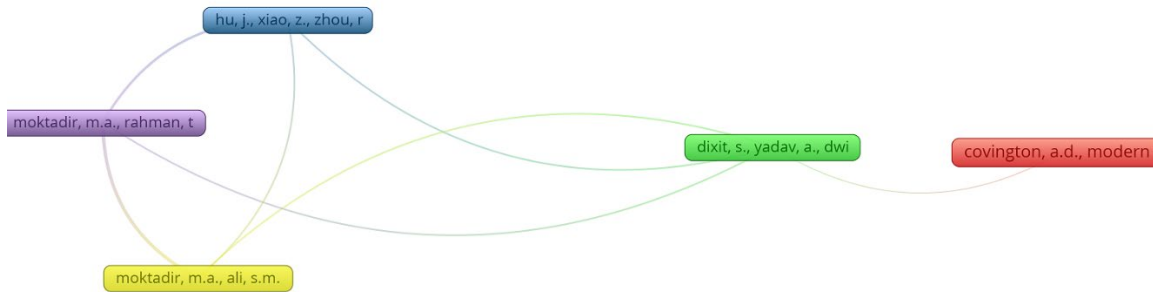


Figure 7. Co-citations network documents

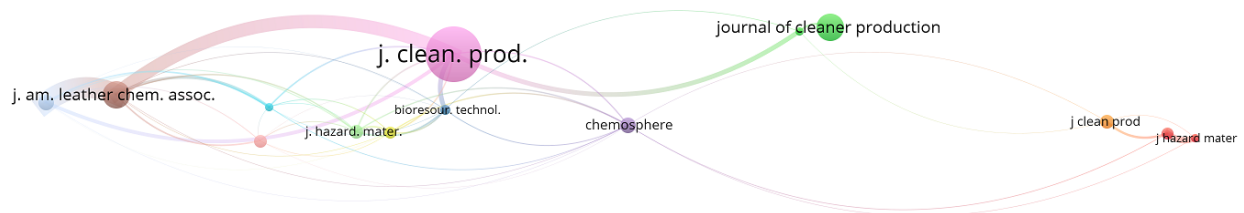


Figure 8. Co-citations network sources

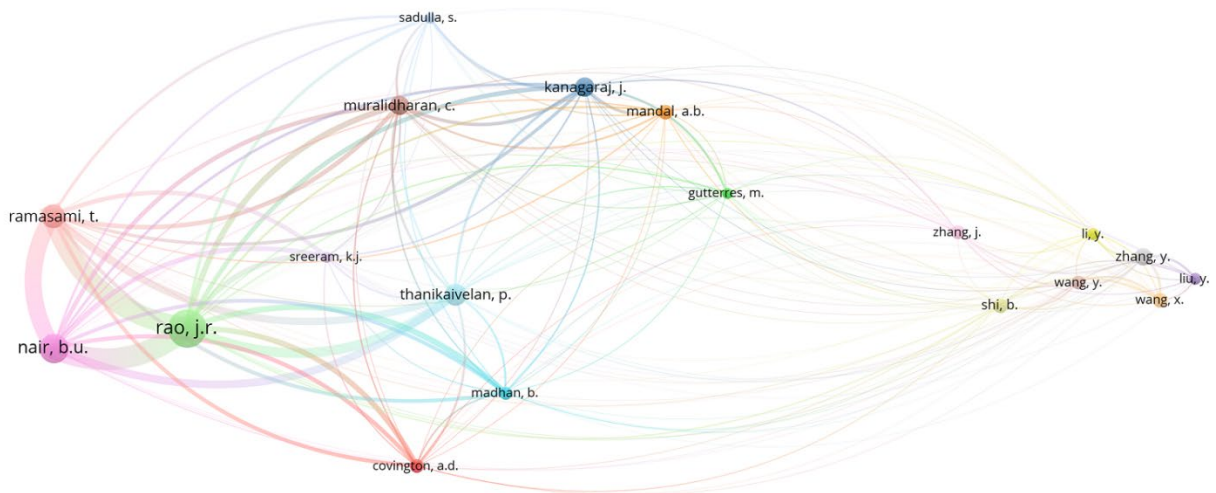


Figure 9. Co-citations network authors

4. Conclusions

This work is a bibliometric analysis of 349 articles extracted from the Scopus database in the domain of social environmental sustainability practices in leather sector. The domain was chosen based on the thrust of researchers in

the sustainability practices, while the leather sector was chosen to spot the pace of application of sustainability interdisciplinary research in this sector. Small number of papers got published in the area of social sustainability practices bibliometric analysis of the searched domain sector was not spotted during the selected time frame. Accordingly, to fill this literature gap, we conducted this bibliometric analysis by bibliometrix R package other open softwares like VOS-viewer. This paper highlights the conceptual structure of the field its evolution over a period. Prior to commencement of this study, certain choices regarding research questions, keywords to be searched, database to be explored analysis tools to be used was made. After data collection, analysis of the collected articles was carried out. Analysis started with the aspect of authors influence followed by affiliation analysis, source relevancy, most cited articles, keywords co-citation analysis. Analysis revealed that, Rao. J. R. is the most contributing author with 8 articles whereas National engineering laboratory for clean technology of leather manufacture, Sichuan University, Chengdu, China is the most relevant affiliating institution with 5 articles India is the most contributing country with 100 co-authorships. Proceedings of the 34th IULTCS Congress: Science Technology for Sustainability of Leather is the most contributing source with 31 documents but with poor citations of only 1 while Journal of Cleaner Production is the most relevant resource with 25 documents more than 941 citations. Igiri et al. 2018 is the most cited documents with 242 citations a Total Citations/year of 80. Leather is the most used keywords with 163 occurrences followed by sustainable development tanning with 131 75 occurrences respectively. Later on co-citation analysis revealed the co-cited authors, documents sources. Furstenau et al. (2020) resulted that the scientific efforts are focused to enhance economic environmental aspects a lack of effort relating the social sphere of sustainability is visible. Our analysis reaffirmed this finding as out of the 349 selected articles in the selected domain in leather sector only 56 documents mentioned the social dimension in some way, further only in 6 articles social aspects occurred as a key word social sustainability occurred only in 1 article as a keyword. This clearly shows the negligence of scientific efforts in social dimensions in leather sector.

5. Limitations future research directions

Through a dynamic analysis, this paper helps to underst the evolution of social environmental sustainability practices in leather sector. However, the work has limitations. The Scopus database was searched, that does not include all journals, enhance many papers might have been omitted. Although this work is based on a single database, the research inferences willaid as a base for futuristic studies. More largely, future researchers may perhaps need to sightsee the other databases too along-with Scopus using various keywords. So, this study may work as a starting point for the upcoming researchers in the presented domain sector.

References

- Akhtar, J., Idris, A., Aziz, R., Recent advances in production of succinic acid from lignocellulosic biomass. *Applied Microbiology Biotechnology*, 98, 987-1000, 2013.
- Al-Subaie, A. A., Faisal, M. N., Aouni, B., Talib, F., A Strategic Framework for Transformational Leadership Development in Megaprojects. *Sustainability*, 13(6), 3480, 2021.
- Alaoui, M. A., Ezzine, M., Azzi, M., Applying the principles of sustainable development in the leather industry in Morocco: Tannery case. *International Journal of Environment Sustainable Development*, 11(2), 2012.
- Aria, M., Cuccurullo, C., Bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics*, 11(4), 959–975, 2017.
- Ashebre, M., Performance of Leather Uppers of Local Footwear products the Determinants. *International Journal of Advancements in Research and Technology*, 3(3), 26–30, 2014.
- Bartelmus, P., Use usefulness of sustainability economics. *Ecological Economics*, 69(11), 2053–2055, 2010.
- Bhatt, Y., Ghuman, K., Dhir, A., Sustainable manufacturing. Bibliometrics content analysis. *Journal of Cleaner Production*, 260, 2020.
- Büyüközkan, G., Karabulut, Y., Sustainability performance evaluation: Literature review future directions. *Journal of Environmental Management*, 217, 253–267, 2018.
- Choudhary A., *What is Sustainable Leather?* [Wageningen University, Wageningen], 2017.
- Deshmukh, R., Khardenavis, A. A., Purohit, H. J., Diverse Metabolic Capacities of Fungi for Bioremediation. *Indian Journal of Microbiology*, 56, 247–264, 2016.
- Dornfeld David A., *Green Manufacturing, Fundamentals Applications*, Springer, 2013.
- El Baz, J., Iddik, S., Green supply chain management organizational culture: a bibliometric analysis based on Scopus data (2001-2020). *International Journal of Organizational Analysis*, 30(1), 156–179, 2022.
- Ellegaard, O., Wallin, J. A., The bibliometric analysis of scholarly production: How great is the impact? *Scientometrics*, 105(3), 1809–1831, 2015.

- Fahimnia, B., Sarkis, J., Davarzani, H., Green supply chain management: A review bibliometric analysis. *International Journal of Production Economics*, 162, 101–114, 2015.
- Figge, F., Hahn, T., Sustainable Value Added—measuring corporate contributions to sustainability beyond eco-efficiency. *Ecological Economics*, 48(2), 173–187, 2004.
- Furstenau, L. B., Sott, M. K., Kipper, L. M., MacHado, E. L., Lopez-Robles, J. R., Dohan, M. S., Cobo, M. J., Zahid, A., Abbasi, Q. H., Imran, M. A., Link between Sustainability Industry 4.0: Trends, Challenges New Perspectives. *IEEE Access*, 8, 140079–140096, 2020.
- Gani, A., Asjad, M., Talib, F., Prioritization Ranking of indicators of sustainable manufacturing in Indian MSMEs using fuzzy AHP approach. *Materials Today: Proceedings*, 46(xxxx), 6631–6637, 2020.
- González, A. L., Martín, J. Á. C., Vaca-Tapia, A. C., Rivas, F., How sustainability is defined: An analysis of 100 theoretical approximations. *Mathematics*, 9(11), 1308, 2021.
- Igiri, B. E., Okoduwa, S. I. R., Idoko, G. O., Akabuogu, E. P., Adeyi, A. O., Ejiogu, I. K., Toxicity Bioremediation of Heavy Metals Contaminated Ecosystem from Tannery Wastewater: A Review. *Journal of Toxicology*, 2018.
- James, A., Gani, A., Tom, A., Asjad, M., Talib, F., Development of a manufacturing sustainability index for MSMEs using a structural approach Development of a manufacturing sustainability index for MSMEs using a structural approach. *Journal of Cleaner Production*, 353(April), 131687, 2022.
- Kanagaraj, J., Senthilvelan, T., Pa, R. C., Kavitha, S. Eco-friendly waste management strategies for greener environment towards sustainable development in leather industry: A comprehensive review. In *Journal of Cleaner Production*, Vol. 89, 1-17, 2015.
- Mironov, V., Trusk, T., Kasyanov, V., Little, S., Swaja, R., Markwald, R., Biofabrication: a 21st century manufacturing paradigm. *Biofabrication*, vol. 1, no. 2, 22001, 2009.
- Moktadir, M. A., Rahman, T., Rahman, M. H., Ali, S. M., Paul, S. K., Drivers to sustainable manufacturing practices circular economy: A perspective of leather industries in Bangladesh. *Journal of Cleaner Production*, 174, 1366–1380, 2018.
- Molamohamadi Zohreh Ismail Napsiah., Developing a New Scheme for Sustainable Manufacturing. *International Journal of Materials, Mechanics Manufacturing*, 1(1), 1–5, 2013.
- Moldavska, A., Welo, T., The concept of sustainable manufacturing its definitions: A content-analysis based literature review. In *Journal of Cleaner Production*, vol. 166, pp. 744–755, 2017.
- Paul, I. D., Bhole, G. P., Chaudhari, J. R., A Review on Green Manufacturing: It's Important, Methodology its Application. *Procedia Materials Science*, 6, 1644–1649, 2014.
- Ramachrana, L. Alagumurthia, N., Application of key performance indicators in a leather shoe industry for leanness analysis using multicriteria approach:A pre implementation study. *International Journal of Advance Industrial Engineering*, vol. 1, 43–47, 2013.
- Rosen, M. A., Kishawy, H. A., Sustainable Manufacturing Design: Concepts, Practices Needs, *Sustainability*, 4, 154–174, 2012.
- Thanikaivelan, P., Rao, J. R., Nair, B. U., Ramasami, T., Recent Trends in Leather Making: Processes, Problems, Pathways. *Critical Reviews in Environmental Science Technology*, 35(1), 37–79, 2005.
- Tseng, M. L., Islam, M. S., Karia, N., Fauzi, F. A., Afrin, S., A literature review on green supply chain management: Trends future challenges. *Resources, Conservation Recycling*, 141, 145–162, 2019.

Biographies

Pankaj Kumar Tyagi graduated from the H.B.T.I., Kanpur, India, with a bachelor's degree in Leather Technology in 2003 received a Master's Degree in Leather Technology from Government College of Engineering and Leather Technology, Kolkata, India. He is a Ph.D. cidate at the Aligarh Muslim University, Aligarh, India. He is currently the faculty at University Polytechnic, Aligarh Muslim University, Aligarh.

SheebaJilani did her B.Sc. Engineering (Chemical) M.Sc. Engineering (Petroleum processing) from AMU Aligarh, PhD from IIT Roorkee. With an experience of more than 31 years, she is actively engaged in teaching research in the areas of modeling of chemical engineering systems, separation processes, waste to energy conversion, environmental pollution abatement.

Faisal Talibis currently a Professor in the Department of Mechanical Engineering, Zakir Husain College of Engineering and Technology, Aligarh Muslim University (AMU), Aligarh, (U.P.), India. He holds a Ph.D. degree from IIT Roorkee master's in industrial engineering from AMU. He has 25 years of teaching research experience

has more than 100 publications to his credit in national/international journals conferences. His special interest includes Total Quality Management (TQM), Sustainability, Operations Management, Multi-Criteria Decision Making (MCDM) techniques, Quantitative research. Additionally, he is a member of various advisory boards/editorial boards of International Journals serving as an expert reviewer in the review panel of several International Journals of repute.