Textile & Leather Review

ISSN 2623-6281 | www.tlr-journal.com | 10.31881/TLR

A Bibliometric Review of Green Technology-Related Research in the Textile Industry

Md. Sadrul Islam Sarker, Istvan Bartok

How to cite: Sarker MSI, Bartok I. A Bibliometric Review of Green Technology-Related Research in the Textile Industry. Textile & Leather Review. 2023; 6:813-836. https://doi.org/10.31881/TLR.2023.182

How to link: https://doi.org/10.31881/TLR.2023.182

Published: 21 December 2023

A Bibliometric Review of Green Technology-Related Research in the Textile Industry

Md. Sadrul Islam SARKER[1,2*], Istvan BARTOK[1]

[1]Alexandre Lamfalussy Faculty of Economics, University of Sopron, Sopron, 9400, Hungary

[2]Department of Management Studies, Begum Rokeya University, Rangpur, 5400, Bangladesh

*sadrul@brur.ac.bd

Article

https://doi.org/10.31881/TLR.2023.182

Received 21 November 2023; Accepted 15 December 2023; Published 21 December 2023

ABSTRACT

Despite being an impressive contributor to the world economy, traditional production and processing methods in the textile manufacturing industry cause significant waste and pollution. Green technology has emerged as a viable approach for mitigating environmental consequences. Numerous scholars have investigated green technologies; nonetheless, a more thorough analysis of the development and characteristics of green technology research in the textile industry is needed. This bibliometric study examined the growth patterns and trends of green technology research in the clothing industry from 2000 to 2023. The data were collected from the Scopus database, and the bibliometric analysis tool VOSviewer was used to visualise the data. The study results demonstrated the exponential growth trends of green textile technology research since 2020. The study also uncovered productive journals, countries, and institutions researching green textile technology. The results additionally showed that the United States (US), the United Kingdom (UK), and China exhibit substantial publications, and the UK is the leading country for collaborative research in green textile technology research. This study identified five primary research areas in the green textile technology literature: environmental impact assessment, life cycle assessment of textiles, sustainable design of textiles, sustainable fashion, and circular fashion supply chains. This analysis can assist academics in identifying novel research methodologies.

KEYWORDS

textile industry, green technology, bibliometric analysis

INTRODUCTION

The textile industry, which generates an estimated $2.4 trillion in annual revenue and employs 300 million people throughout the supply chain, is one of the largest manufacturing sectors in the world [1]. It plays a significant role in enhancing the socioeconomic development of the global economy, especially in developing countries [2]. However, the use of unethically processed natural or synthetic fibres and the high water, chemical, and energy requirements of the textile industry are detrimental to the environment [3,4]. Textile manufacturing processes contribute to 20% of global wastewater and $100 billion annually in wasted resources due to inefficiency and improper disposal, and 9% of microplastics are lost to the ocean each year [1,5,6]. Green technologies are alternative approaches to production and processing that can reduce pollution and ecological crises and boost resource, water,

and energy efficiency. These products have emerged to reduce the negative environmental impacts of textiles and promote global sustainability [5,7,8]. Clothing manufacturers are attempting to replace traditional technologies with greener alternatives due to increased global regulations, government pressure, and growing public awareness concerning environmental protection [9]. Many world-class fashion manufacturers, such as Schoeller Textil AG and Flex apparel, and numerous fashion brands, such as the Swedish fashion retailer H&M, the American fashion seller Patagonia, and the French fashion retailer Louis Vuitton have adopted various green technologies to mitigate potential negative social and environmental consequences and meet rising stakeholder expectations [10–12].

The term "green technology" encompasses a variety of disciplines and is constantly evolving. Green technologies are alternatives to traditional technologies that promote ecological sustainability while meeting the needs of humans and the natural world [13–15]. These technologies are characterized as resource- and energy-efficient approaches that help to reduce the environmental challenges of the manufacturing industry [11,16,17]. Many terms are related to green technology, including sustainable practices [18,19], cleaner technologies [20,21], environmentally sustainable practices [22,23], and green manufacturing approaches [24,25].

The unique characteristics of green textiles include eco-design [10] and biodegradable fibres [26], renewable energy [27], alternative water treatments [28], circular textiles [29], three-dimensional (3D) printing [30,31], and digital textiles [32] are considered green technologies in the textile manufacturing industry. Nayak et al. conceptualised sustainable technologies as those that do not deplete natural resources [2]. These include enzyme processing, natural dyeing, laser technology, digital printing, and plasma technology. Green technologies are also called cleaner technologies that support sustainable development [20]. Although many have attempted to define the terms associated with green technologies, no consensus definition has yet emerged [7,33]. This study illustrates that green technologies are eco-friendly approaches that benefit both people and the environment by decreasing pollution and increasing productivity and safety.

Green technologies are gaining popularity in the academic community, governments, and the textile industry worldwide because of their potential to improve environmental sustainability [7,27,34]. Many researchers have conducted studies on green technologies in the textile industry from various vantage points. According to research by Ahmad et al., creating eco-friendly clothing lines could aid in the fight against climate change [35]. The authors suggested that the textile industry should embrace green technologies to reduce pollution and waste. Mazotto et al. illustrated that textile manufacturing is one of the most polluting industries because it uses the equivalent freshwater of several lakes, releases dangerous chemicals into the environment, contributes to microplastic pollution through the use of synthetic fibres, uses up nonrenewable resources, and accelerates global warming more than

international aviation and shipping put together [36]. They revealed that the textile industry as a whole needs to adopt alternative technologies to reduce their negative effects on the environment. For instance, green technologies, eco-friendly and biodegradable raw materials, green manufacturing techniques, a green supply chain, and conscientious buyers contribute to sustainable fashion and textiles [3,8,9,25]. The textile supply chain needs cleaner technologies because producing textiles and fabrics requires a high volume of water, chemicals, and energy, especially during dyeing [11,37–39]. Textile sustainability depends strongly on the adoption of environmentally friendly approaches [22,40]. This research considers "green textiles" and "green textile technologies" synonymous.

Researchers across the globe have extensively examined green technology in the textile sector. However, the evolution of research topics and patterns in performance still needs to be clarified. Examining the current trend of research and identifying leading research institutions, authors, journals, and inter-university and inter-author collaborations in the field of research can assist researchers in comprehending the extent of research more thoroughly and determining future research directions [41]. Consequently, it is critical to perform comprehensive research involving the systematic collection and analysis of data to understand the research efforts on green technologies in the textile industry. To the best of the authors' knowledge, this study represents an inaugural bibliometric analysis of the rise of green technology throughout the textile industry's global supply chain. This study used a bibliometric analysis of global scientific publications to assess the status of green textile technology.

Bibliometric methods are frequently employed across several academic disciplines such as business [42], management [43], marketing [44,45] and waste management [46], to examine scientific output and research patterns. These are statistical tools used to study the literature quantitatively and comprehensively [43]. Given this background, the current study intends to answer four specific research questions (RQs):

RQ1: What is the landscape of green technology research in the textile supply chain?

RQ2: Which are the prolific journals, countries, and institutions in green textile technology literature?

RQ3: What are the most influential collaboration networks of countries in green textile technology research?

RQ4: What are the major themes in the green textile technology literature?

This study contributes to the green technology literature by conducting a bibliometric analysis of 960 articles published in academic journals. To answer RQ1 and RQ2, the performance analysis technique was used. A co-authorship network of countries was employed to answer RQ3, and a keyword co-occurrence map (keyword cluster analysis) was constructed to address RQ4.

By addressing the abovementioned research questions this study makes significant theoretical and practical contributions to the green technology literature on textile supply chains. From the theoretical perspective, this study uncovers the knowledge clusters (major theme) of green technology and social relationships (coauthorships) for knowledge development [47]. From a practical point of view, this study improves practice by revealing new trends in green technology articles and journals, patterns of collaboration, and research groups [48].

The remainder of this research paper is organised in the following manner: the data collection sources, search strategy, and data analysis procedures are discussed in the methodology section of this research; the research findings and discussion have been added to the Results and Discussion sections. Finally, the conclusion, limitations, and future directions are presented.

METHODOLOGY

Data Source and Identification

For bibliometric analysis, researchers can conduct searches and collect data from a wide variety of bibliographic sources. Scopus and Web of Science (WoS) are the two most prominent databases. The bibliometric results may be different for each database [49]. Scopus has a broader range of journals and records of publications than does the WoS [50]. The Scopus database was chosen for our study in light of the recent bibliometric study on green technology [51]. The guidelines for bibliometric analysis developed by Donthu et al. recommended the use of a single database for conducting bibliometric analysis [48]. Moreover, this study used only the Scopus database because of the use of previous bibliometric reviews in this domain and the convenience of the study [51,52]. The researchers employed a search query to identify pertinent research documents by utilizing search categories such as titles, abstracts, and keywords. Search keywords were chosen based on past relevant reviews [22]. To ensure the comprehensive inclusion of relevant papers, a combination of logical operators (namely, OR and AND), wildcards (represented by *), and synonyms of green technologies were employed. The search process for relevant papers was conducted only once to mitigate potential bias resulting from the continual update of the Scopus database. When the search terms were run in the advanced search of Scopus on September 1, 2023, the search yielded a total of 1937 documents on research on green technology in the textile industry. These documents spanned various subject areas, including but not limited to engineering, environmental science, materials science, business, management and accounting, chemistry, social sciences, medicine, computer science, and mathematics. Hence, there is an increased likelihood of certain papers being inconsequential to the present research. Consequently, all of these research papers underwent additional scrutiny utilizing suitable filters. The researchers

applied a range of filters to obtain genuinely relevant documents from the study's document pool, as recommended by Kraus et al. [53]. First, the researchers restricted their search period from January 2000 to August 2023 because papers published before 2000 were irrelevant to the studied topic [54]. Second, the researchers only consider publications in English because it is the de facto international language for sharing scientific knowledge [43]. Third, all the materials must be published in their final versions [53]. After that, the search query returned a total of 1807 papers that were ready to be extracted from the database. The researcher employed the following search string which is replicable: TITLE-ABS-KEY (("Green* technolog*" OR "Green practices" OR sustainabl* OR "Sustainable strateg*" OR "Sustainable practic*" OR "Sustainable approach*" OR "Biological approach*" OR "Waste management" OR "Wastewater treatment*" OR "Circular economy" OR "Waste valorizations" OR "Cleaner options" OR "Environmental practices") AND ("Textile industr*" OR textile* OR "Fashion industr*" OR fashion OR "Clothing industr*" OR "Apparel industr*" OR apparel OR garments OR clothing)) AND PUBYEAR > 1999 AND PUBYEAR < 2024 AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (PUBSTAGE, "final")). Figure 1 depicts the data search and screening flow of this study.

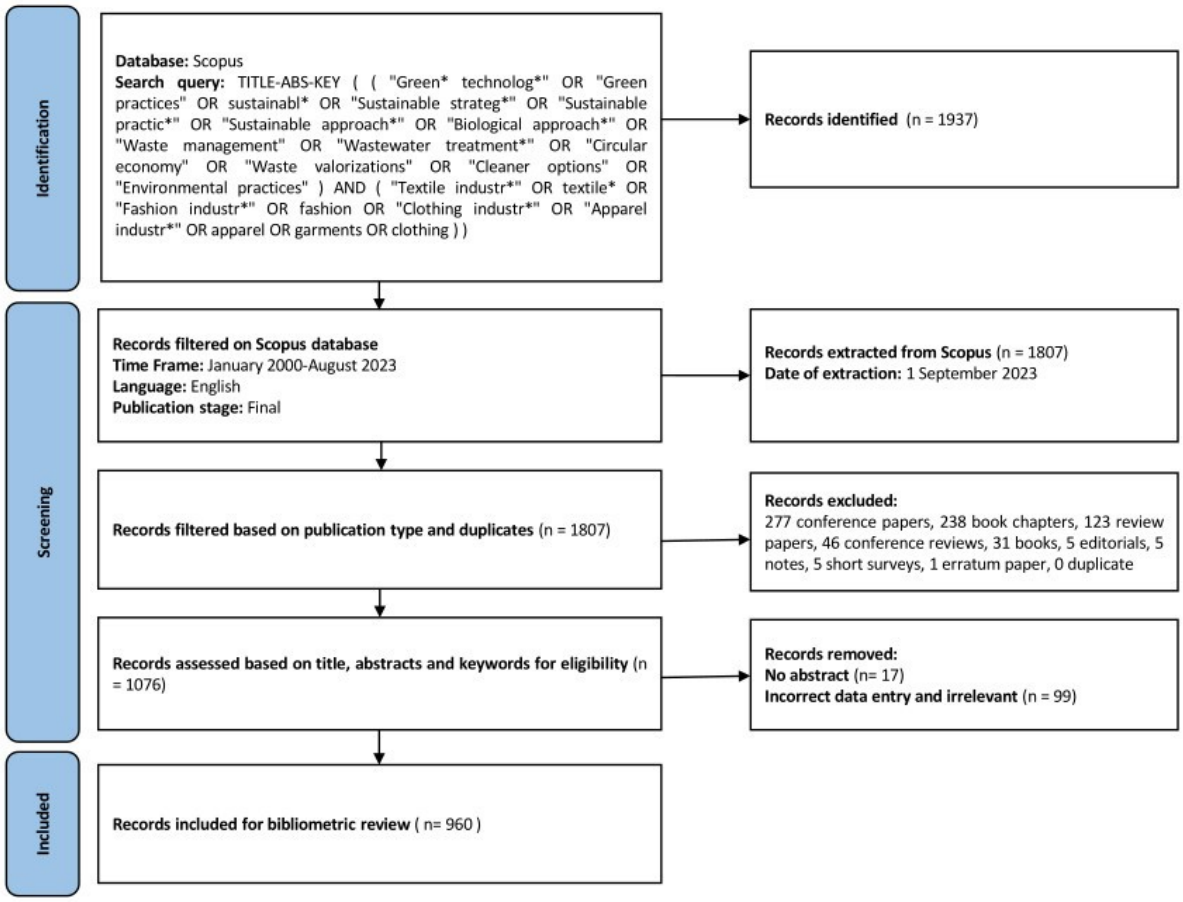

Figure 1. Data search and screening flow diagram; Source: Adapted from Page et al. [55]

Extraction and Cleaning of Research Data

Following the identification of bibliometric data, the authors proceeded to export the data from the Scopus database into a file formatted with comma-separated values (.csv). The researchers identified 1076 original research articles by applying filters to the extracted data records from Scopus based on the type of publication and duplication. Subsequently, the researchers conducted the data cleansing and verification of relevant research papers. Data cleansing procedures were conducted to detect missing or inaccurate input entries by meticulously examining the field columns to confirm the absence of any crucial omissions in the data. Additionally, it was verified that the data within each field aligned appropriately with the corresponding field title. The researchers read the title, abstract, and keywords of the papers to identify only relevant articles on green technologies in the textile industry. The researchers finally included 960 original research articles for bibliometric review.

Data Analysis Techniques

Bibliometric analysis can be performed in two ways: through performance analysis and science mapping [48]. While performance analysis assesses how each research element contributes to a specific topic, science mapping examines the interrelationships between research elements such as institutions, countries, and publications [47,48]. At the beginning of the analysis, performance analysis (quantitative and qualitative) was used to identify the research output and determine the journal impact factors and citation rates. The evaluation consists of the following steps: (1) determining the trends in contributions to green technology research via Scopus; (2) identifying the journals with the highest number of citations, the top ten journals; (3) identifying the leading countries in terms of author affiliation, the top ten countries; (4) identifying the highest performing academic institutions in terms of research output, the top ten institutes. The publication trends were analysed using Microsoft Excel. Science mapping techniques, namely, network analysis and keyword cluster analysis, were used to assess the connections between countries and institutions and to understand the major themes in the green technology literature in the textile industry. The user-friendly VOSviewer, version 1.6.19, was used to visualise bibliometric networks and maps [56,57].

RESULTS AND DISCUSSION

The present study presents the findings derived from the analysis that was performed. The performance assessment techniques focus on examining the bibliometric framework of scholarly publications across various dimensions. In contrast, science mapping reveals the country's collaboration patterns and major themes underpinning its intellectual structure.

Publications Trends

Figure 2 shows the trends in Scopus publications on green technology research in the textile industry. The search conducted in the Scopus database yielded a total of 1807 publications on green textile technology, which were published between 2000 and 2023. Researchers have applied several filtering methods to accurately represent green technology in the textile industry. Therefore, this study analysed green textile research trends based on 960 articles. The graphs illustrate a consistent increase in publications on green textile technology over the years. During the first decade, research on environmentally friendly textiles exhibited limited progress. The number of publications increased from two in 2000 to 54 in 2017. After that, it showed a constantly increasing trend beginning in 2019. More importantly, clear and notable exponential growth has been observed in the number of articles published since 2020. The recent rising trends in green technology research in the textile sector can be traced to developing new avenues of inquiry. Therefore, environmentally friendly solutions are emerging as viable alternatives for promoting sustainable development in the textile sector.

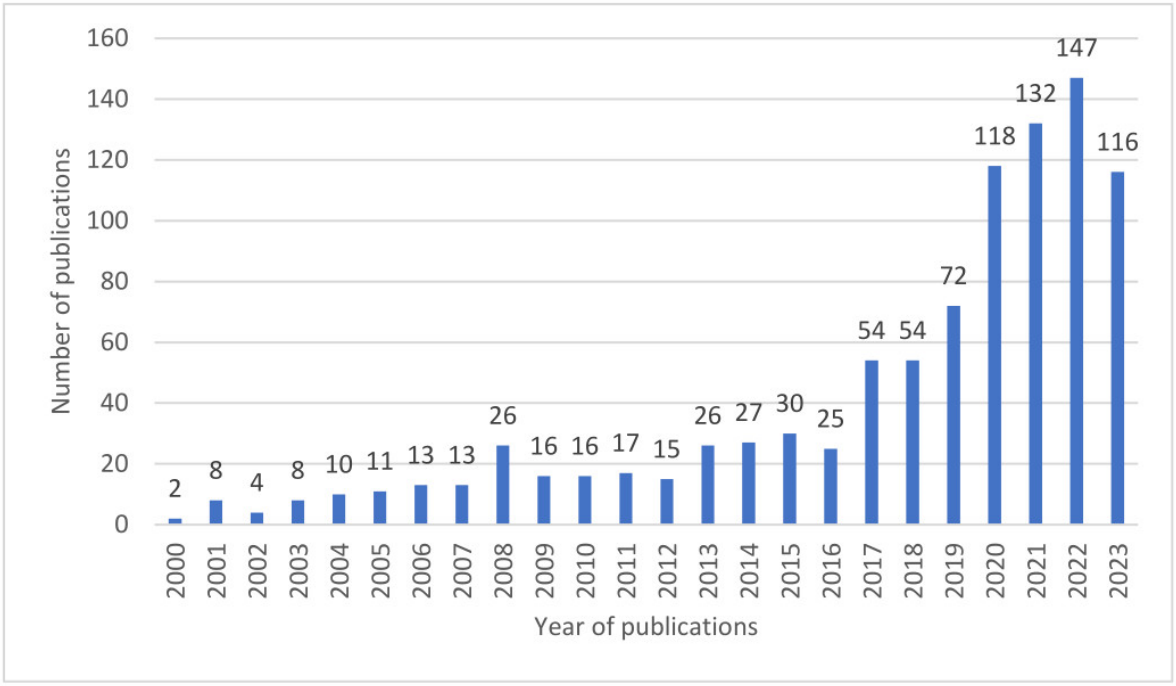

Figure 2. Publication trends in green technology research for textiles

Thematic Area of Research

Figure 3 shows the top 10 Scopus subject categories of green textile technology research conducted during the past 23 years. The analysis of subject categories provides valuable insights into the interconnectedness of various disciplines. The Scopus subject category of Environmental Science is the

leading category with 389 papers (40.52% of 960 publications), followed by Business, Management and Accounting, with 354 papers (36.87%); Materials Science, with 294 papers (30.62%); and Engineering with 260 papers (27.08%), Social Sciences with 211 papers (21.98%), and Energy with 200 papers (20.83%). There were 93 computer papers (9.68%), 63 economics, econometrics and finance papers (6.56%), 62 arts and humanities papers (6.45%) and 60 chemical engineering papers (6.25%). The cumulative percentage of subject categories exceeded 100% due to the possibility of journals being assigned to multiple subject categories. This observation highlights the strong association between Environmental Science and other disciplines, emphasizing the increasingly interdisciplinary nature of this field.

Every academic discipline has a specific area of concentration. Research on a particular topic may connect to numerous study fields. The lack of a dedicated research domain for green textile technologies in Scopus demonstrates the multifaceted nature of this field of study. However, environmental science is the central theme, fostering the pursuit of sustainable solutions for textile emissions and waste. Finally, the Scopus study indicates that green technology research in the textile industry has focused primarily on the environmental sciences, business, management, accounting, and materials science. Social science, economics, econometrics, and finance disciplines focus less on eco-friendly issues than does environmental science. On the other hand, disruptions to natural ecosystems caused by conventional textile manufacturing processes continue to attract increasing attention, leading to new methods for incorporating sustainability into textiles and expanding the scope of environmental science research.

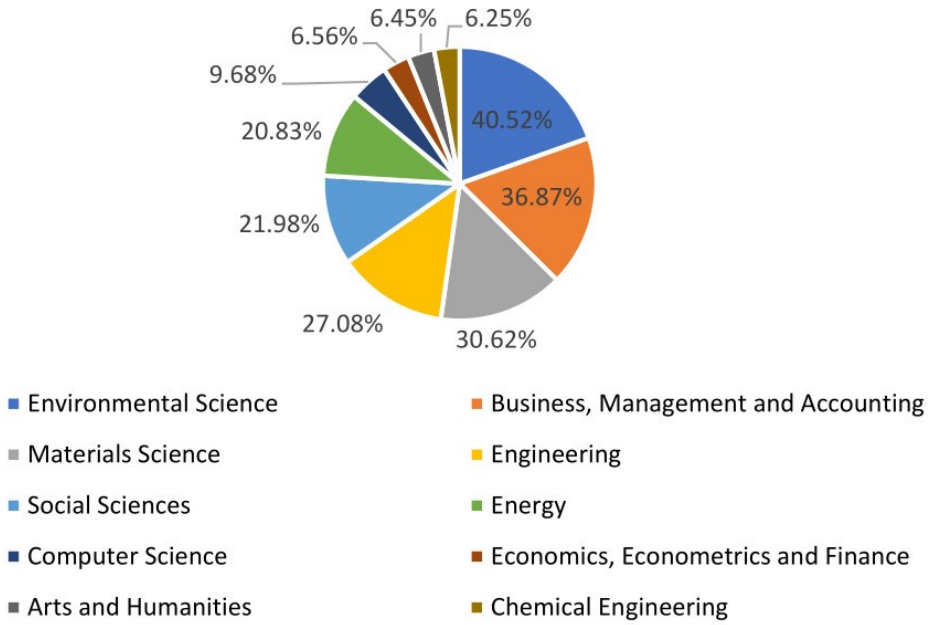

Figure 3. Research documents by subject area in Scopus

Most Prolific Journals

Scientific journals serve as a means of disseminating research findings and providing researchers with valuable information regarding the primary outlets through which they can share their research outcomes [58]. The researchers found 960 research documents on green textile technology spread across 376 publications. Notably, 30 of these journals have published more than five articles on this specific topic. To determine the most influential and widely read journals in green textile technology research, only those that had at least 10 articles published and 100 citations were considered. Only eight journals met the specified criteria (see Table 1). These findings will enable researchers to identify prospective journals for publishing their research papers.

Total publications and citations determine the ranking of the journal. A journal with more publications was ranked higher. Similarly, a journal with more citations is rated higher, and so on [45]. It is noteworthy that a majority of these journals are classified under the Q1 and Q2 categories as per the Scimago Journal rankings. This scenario implies the importance of green textile technology research. Scientific journals serve as a means of disseminating research findings, providing researchers with valuable information regarding the primary outlets through which they can share their research outcomes. It is also important to note that all the top journals except one have a greater than one source normalised impact per paper (SNIP) score. The SNIP calculates a journal's average citations per paper as a percentage of the journal's total possible citations for that field of study [59]. All of these leading journals have a notable influence on the citation rates in their respective fields. Therefore, these findings will provide prospective scholars with valuable insights into suitable journals for publishing their research.

Table 1. Most Prolific Journals

Name of Journal	TP	TPR	TC	TCR	JIF	CiteScore	SNIP	SJR	Q
Sustainability (Switzerland)	86	1	1415	2	3.9	5.8	1.198	0.66	Q1
Journal of Cleaner Production	62	2	2319	1	11.1	18.5	2.379	1.98	Q1
Journal of Fashion Marketing and Management	17	3	548	5	3.5	7.9	1.764	1.27	Q1
Journal of The Textile Institute	14	4	309	6	1.7	3.7	1.046	0.38	Q2
International Journal of Consumer Studies	13	5	901	3	9.9	10.3	2.29	1.75	Q1
Resources, Conservation and Recycling	13	6	568	4	13.2	20.3	2.771	2.68	Q1
Research Journal of Textile and Apparel	11	7	176	7	1.5	2.2	1.172	0.38	Q2
Textile Research Journal	10	8	120	8	2.3	4.4	1.329	0.47	Q2

Note: TP- Total Publications; TPR- Total Publications Ranking; TC- Total Citations; TCR – Total Citations Ranking

Most Influential Countries

In the present study, research on green technologies for textiles has garnered attention in 100 countries globally. Figure 4 provides a clear representation of the quantity of publications in the

leading 10 countries. These countries collectively accounted for 62.81% of the overall publications on green textile technology research. This study indicated that the United States (US), China, India, the United Kingdom (UK), Germany, Italy, Australia, Brazil, Portugal and Romania are quite active in researching green textiles. Almost 13% of the research articles were published in the U.S. (120 publications). The increase in output publications from two in 2006 to 14 in 2023 demonstrates that the United States has made significant progress in green textile technology studies. This notable advancement has led the US to reach the top position in this field by 2023. The analysis of country publication data reveals which country prioritizes green textile technology research. The study's findings indicate that the U.S., China, India, and the UK significantly contribute to research on green technologies in the textile industry.

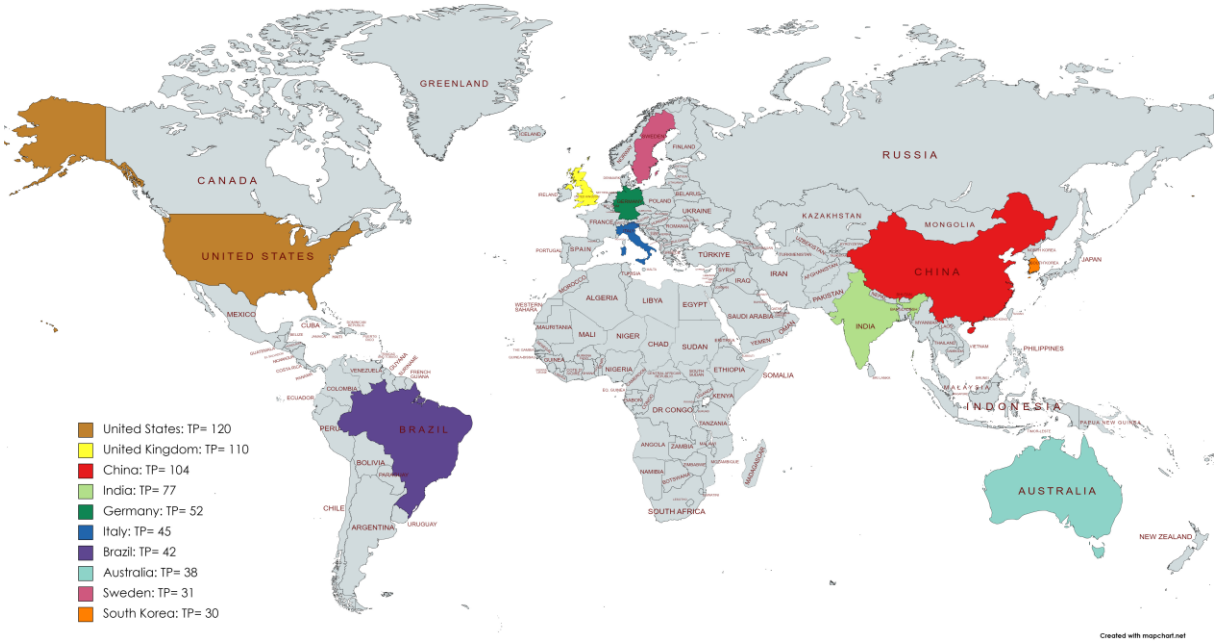

Figure 4. Number of publications for each geographical region on the world map. The map was generated using the following web link: https://mapchart.net/world.html

Productive Institutes

Institutional analysis provides insight into specific areas of study, such as the leading academic institutions in the discipline. According to Scopus data, Table 3 displays the leading academic institutions from three countries, namely, the UK (2 institutions), South Korea (1 institution), and Hong Kong (1 institution), according to the Scopus database. Royal College of Art, London is the most active institute for publishing green textile technologies. The results from institutional analysis in this sector help identify those focusing on green textile research. Thus, researchers in this field or those interested in it can start to collaborate with these institutes.

Table 2. Top institutes publishing papers on green textile technology

Institutes	Country	Number of Publications
Royal College of Art, London	United Kingdom	8
School of Advanced Materials Science and Engineering, Sungkyunkwan University, Suwon	South Korea	5
Institute of Textiles and Clothing, The Hong Kong Polytechnic University	Hong Kong	4
School of Design, University of Leeds, Leeds	United Kingdom	4

Country Collaboration Networks of Green Textile Technology

The global network of scientific collaboration recognises countries that actively participate in research relating to the primary field being examined [60–62]. This study identified the most active country networks by applying coauthorship country network analysis to VOSviewer. The authorship network across countries for publishing research on green textile technology from 2000 to 2023 encompassed 88 countries. A minimum of five publications per nation were applied as a criterion for inclusion, resulting in the selection of 44 countries. These countries were then categorised into six distinct clusters, as depicted in Figure 5. Total link strength values have been employed in the network to depict the most productive countries conducting research into green textile technologies. Total link strength (TLS) measures how researchers in a specific country collaborate with their peers from other countries to produce scholarly works [63,64]. Based on the results of the country collaboration network for green textile technology, it has been found that countries such as the UK, China, and the USA are currently more interested. The existing researchers can improve their connections with researchers from other countries. Readers who want to communicate with other writers and organizations can save time with country collaboration network findings.

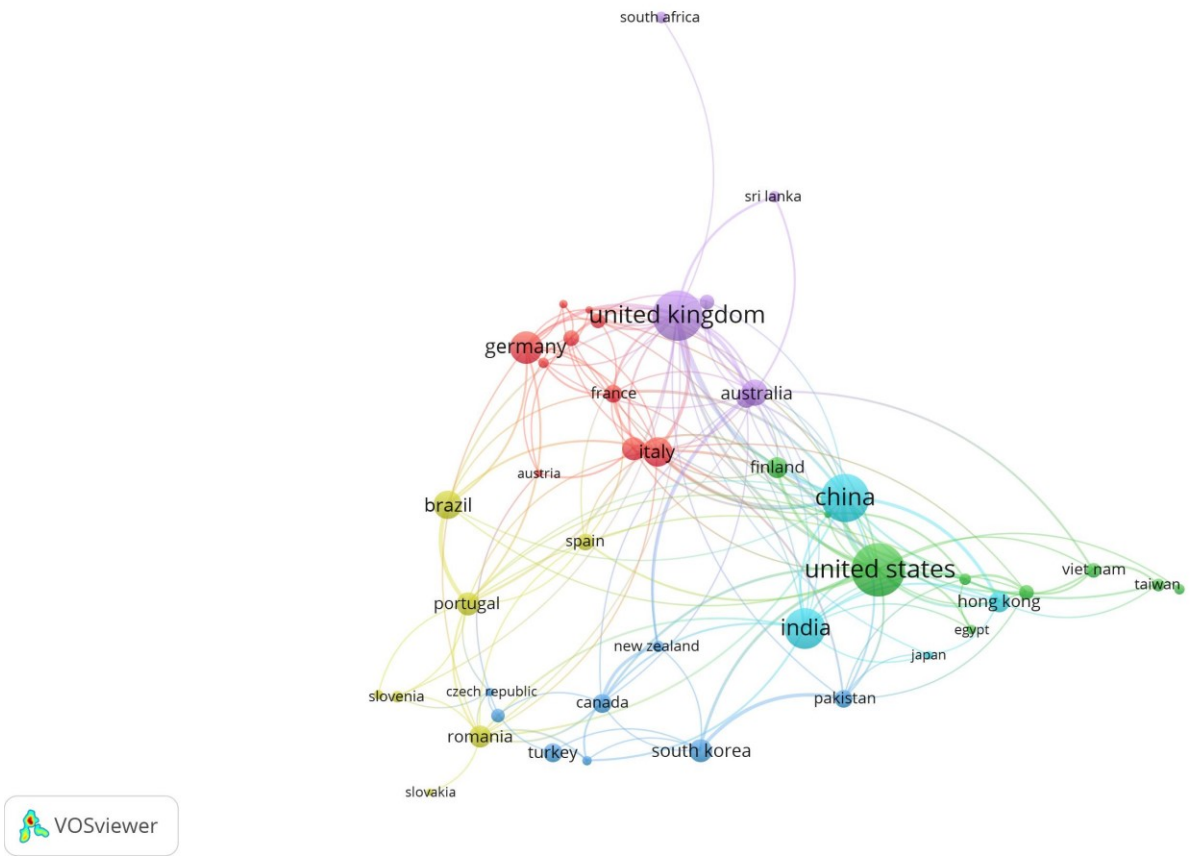

Figure 5. Coauthorship network map of countries

Table 4 displays the top 20 countries ranked according to their total link strength. The United Kingdom has the leading position regarding total link strength, but it does not rank first in terms of total documents and citation count. The United States is one of the countries that contributed the most papers and citations, but it is not at the top of the coauthorship network map of countries (Figure 5). This might be because there is a significant level of domestic research focused on green textile technology, which is separate from substantial global partnerships.

Table 3. Collaboration in the top 20 countries (ranked by total link strength)

Country	Links	Total link strength	Documents	Citations	Cluster
United Kingdom	25	64	110	3507	5
China	19	56	104	3194	6
United States	19	51	120	6754	2
Italy	15	32	45	1841	1
Australia	15	28	38	1395	5
Portugal	12	23	29	378	4
France	13	22	20	580	1
Germany	13	21	52	653	1
India	14	20	77	1193	6

Country	Links	Total link strength	Documents	Citations	Cluster
Bangladesh	8	19	23	308	5
Canada	9	18	21	371	3
Brazil	7	17	42	500	4
Romania	12	17	28	257	4
Pakistan	8	16	20	198	3
Hong Kong	6	14	25	337	6
Saudi Arabia	8	14	9	109	2
South Korea	6	14	30	719	3
Sweden	8	12	31	938	1
Malaysia	7	11	14	144	2
Finland	6	10	26	1449	2

Major Research Themes of Green Technology Research in the Textile Industry

Keyword co-occurrence analysis of bibliometric techniques attempts to identify the major research theme in particular research areas [51,65]. Co-word analysis produces a thematic network that represents the field's intellectual space [45,48]. Therefore, the authors' keyword co-occurrence analysis for the time frame spanning from 2000 to 2023 was conducted to identify recurrent thematic areas of green technologies in the textile industry. A minimum threshold of eight occurrences of keywords was set for this investigation. The research yielded a total of 43 keywords from a pool of 2,719 keywords. The findings indicate the presence of five distinct clusters, as depicted in Figure 6.

Each cluster represents a different area of research in green textile technology. Figure 5 illustrates the classification of the 43 keywords into five distinct colour-coded categories based on their conceptual commonalities. Differently coloured nodes such as red, green, purple, yellow, and blue denote the five different cluster types. The strength of the association between two keywords is determined by the frequency of their co-occurrence in scholarly works, indicating their interconnectedness in terms of research topics [66,67]. Larger nodes imply a higher frequency of keywords, whereas thicker connection lines indicate a strong correlation between terms. In the network map, sustainability has the highest frequency of occurrence (152), followed by circular economy (99), recycling (45), and sustainable fashion (42). By analysing each cluster in the thematic network map, five recurrent themes were identified: "environmental impact assessment" (red cluster), "life cycle assessment of textiles" (green cluster), "sustainable design of textiles" (blue cluster), "sustainable fashion" (yellow cluster), and "circular fashion supply chain" (purple cluster).

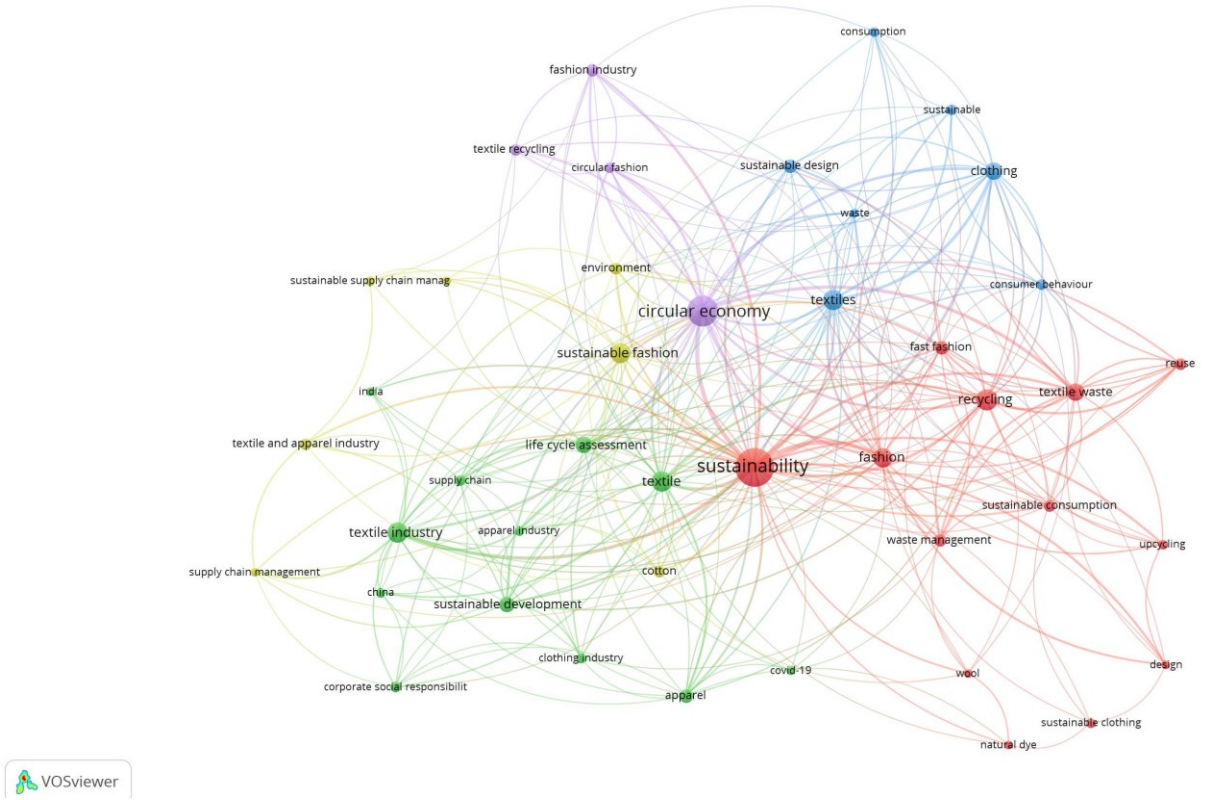

Figure 6. Major research themes with keyword co-occurrence networks

Cluster 1 contains terms related to the ecological implications of the textile industry, including design, fashion, fast fashion, natural dye, recycling, reuse, sustainability, sustainable clothing, sustainable consumption, textile waste, upcycling, waste management and wool [38,68–72]. Cluster 2 encompasses the body of research that focuses on the life cycle assessment of textiles. The important keywords of this cluster are life cycle assessment, supply chain, corporate social responsibility, COVID-19, sustainable development, and textile industry [73–77]. Cluster 3 is comprised of unique keywords that are closely linked to the idea of green design of textiles. This cluster is characterized by keywords such as sustainable design, clothing, consumer behaviour, consumption, sustainable textiles and waste [78–80]. Cluster 4 comprises environmental sustainability, cotton, the environment, supply chain management, sustainable fashion, sustainable supply chain management, and the textile and apparel industry [81–83]. Cluster 5 comprises the predominant terms associated with circular economy principles in the textile sector, such as the circular economy, circular fashion, fashion industry and textile recycling [84–87]. All the clusters are named based on the central research theme of the keywords within the clusters. Overall, the keyword co-occurrence results of the studies made it easier to find the main points of interest in the green textile technology knowledge base. "Sustainability" and "circular economy" are the most frequently occurring keywords in the analysed papers.

Scholars interested in conducting further investigations into green textiles may find some insights in this bibliometric review. The significance of green technology in the textile industry has prompted researchers and professionals to investigate the potential advantages and obstacles associated with its adoption. The keyword co-occurrence analysis of these studies serves as an essential tool for identifying directions for further research. For example, this study grouped the studies based on their conceptual similarities and intellectual structure, which resulted in five clusters: environmental impact assessment, life cycle assessment of textiles, sustainable design of textiles, sustainable fashion, and circular fashion supply chain. The study found limited studies on digital and innovative technologies and green textile models, which can promote sustainability performance in the textile industry. Thus, future studies can address this knowledge gap by conducting empirical studies. In addition, the researchers in this study identified the most prominent journals, countries, and institutions involved in green textile technology research, promoting seminal articles that guide future investigations. To further understand green technology in the textile industry, this research proposes conducting additional investigations that complement the current study. For instance, combining cocitation and bibliographic coupling network analysis will help trace the intellectual structure of the green textile domain and identify future research directions.

This study applied different bibliometric techniques to answer the four research questions and enhance the knowledge mapping of green textile technologies. The researchers used trends and thematic area analysis of green textile technology research to answer RQ1, the landscape of green technology research in the textile supply chain. Journals, countries, and institutional performance were assessed to address RQ2. A coauthorship network analysis was used to respond to RQ3, and a keyword co-occurrence network was employed to answer RQ4, the primary theme in the green textile technology literature.

However, particular areas require further improvement. First, this study was fully conducted based on only the Scopus database; other data sources, such as the Web of Science, Dimensions, and PubMed were not included. Integrating multiple databases for identifying and analysing green textile technology research might provide more insightful results. Second, the time frame for extracting research documents limits the comprehensiveness of this study. This study also restricts its coverage to the English language, so future studies may include research documents in other languages. Finally, the analysis of this study was based entirely on quantitative analysis, and qualitative analysis was absent. Thus, a systematic literature review can be undertaken in the future to combine qualitative and quantitative analysis. Moreover, this study covers common issues of green textiles; therefore, additional research should be carried out on the use of specific green textile technologies, such as enzyme applications and plasma and laser technology, in the textile industry. Furthermore, conducting further research on green textile technology, including a comparative analysis between developed and

developing nations, can contribute to the existing body of knowledge on this subject. Additionally, such a study could foster international cooperation in the field of green textile technology.

CONCLUSIONS

This study was undertaken to present various studies published on green technologies in the textile industry between 2000 and 2023. Green technologies are essential to reduce environmental pollution caused by the conventional textile manufacturing process. This study employed bibliometric analysis to contribute to the current body of knowledge by examining the evolution of green technologies in the textile industry. The study demonstrates a growing academic interest in investigating the potential of green technology in the textile industry. The results reveal a significant increase in the number of research articles focusing on green textile technologies beginning in 2017. Additionally, the study found that the number of publications on green textile technology research crossed triple digits in 2020, marking a turning point in this field. The study also identified the productive journals, countries, and institutions involved in green technology in the textile industry. According to this study, the United States, China, and India are the top countries publishing research on green textile technology. In addition, the United Kingdom is the leading country for collaborative research. Journal Sustainability and the Journal of Cleaner Production are the two prominent publications. The premier research institute for green textile research is the Royal College of Art, London. This review identifies and discusses the primary keywords in the literature, generates knowledge clusters, and suggests avenues for future investigation. The keyword occurrence analysis of this study identified five research themes of green technology research in the textile industry. Recently, topics related to environmental impact, life cycle assessment, green transition, sustainable fashion, and circular textiles have received considerable attention. These prominent research themes guide academics, professionals, and policymakers towards green technologies in the textile industry. The findings of this study can assist scholars in identifying the many streams and patterns involved in global research on green textile technology, enabling them to suggest future research areas. Researchers can use this study's result to prioritise their efforts towards investigating unexplored areas that will contribute to the progress of green textile research. Moreover, they can find active institutes and countries from this study to seek potential collaborators for further research. However, this study acknowledges its limitations and reinforces the need for future investigations incorporating multiple data sources, multilingual documents, and qualitative analysis.

Author Contributions

Conceptualization – Sarker MSI; methodology – Sarker MSI and Bartok I; formal analysis – Sarker MSI; investigation – Sarker MSI; resources – Sarker MSI; writing-original draft preparation – Sarker MSI; writing-review and editing – Sarker MSI and Bartok I; visualization – Sarker MSI; supervision – Bartok I. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

Funding

This research received no external funding.

REFERENCES

[1] Adamkiewicz J, Kochańska E, Adamkiewicz I, Łukasik RM. Greenwashing and sustainable fashion industry. Current Opinion in Green and Sustainable Chemistry. 2022; 38:100710. https://doi.org/10.1016/J.COGSC.2022.100710

[2] Nayak R, Panwar T, Nguyen LV. Sustainability in fashion and textiles: A survey from developing country. In: Nayak R, editor. Sustainable Technologies for Fashion and Textiles. Cambridge, UK: Woodhead Publishing; 2020. p. 3-30. https://doi.org/10.1016/B978-0-08-102867-4.00001-3

[3] John EP, Mishra U. A sustainable three-layer circular economic model with controllable waste, emission, and wastewater from the textile and fashion industry. Journal of cleaner production. 2023; 388:135642. https://doi.org/10.1016/J.JCLEPRO.2022.135642

[4] Gunturu KPK, Kota KK, Sharma M. Energy Efficiency Improvement Opportunities in Indian Textile Industries. Textile & Leather Review. 2022; 5:296-326. https://doi.org/10.31881/TLR.2022.13

[5] Ikram M. Transition toward green economy: Technological Innovation's role in the fashion industry. Current Opinion in Green and Sustainable Chemistry. 2022; 37:100657. https://doi.org/10.1016/J.COGSC.2022.100657

[6] Rendón-Castrillón L, Ramírez-Carmona M, Ocampo-López C, González-López F, Cuartas-Uribe B, Mendoza-Roca JA. Treatment of water from the textile industry contaminated with indigo dye: A hybrid approach combining bioremediation and nanofiltration for sustainable reuse. Case Studies in Chemical and Environmental Engineering. 2023; 8:100498. https://doi.org/10.1016/j.cscee.2023.100498

[7] Nayab-Ul-Hossain AK, Sela SK, Nehal K, Hasan N, Hossain MI, Jalil MA. Application of green technology to treat fibrous (textile) waste and recycling of used chemicals for reutilization of

similar waste. Cleaner Engineering and Technology. 2023; 13:100625. https://doi.org/10.1016/J.CLET.2023.100625

[8] Xu X, Cui X, Zhang Y, Chen X, Li W. Carbon neutrality and green technology innovation efficiency in Chinese textile industry. Journal of Cleaner Production. 2023; 395:136453. https://doi.org/10.1016/J.JCLEPRO.2023.136453

[9] Zheng S, Jiang C, Fu X, Ge YE, Shu J. Subsidies for green technology adoption under uncertain demand and incomplete information. Omega. 2022; 112:102675. https://doi.org/10.1016/J.OMEGA.2022.102675

[10] Wang L, Shen B. A product line analysis for eco-designed fashion products: Evidence from an outdoor sportswear brand. Sustainability. 2017; 9(7):1136. https://doi.org/10.3390/SU9071136

[11] Shen B, Zhu C, Li Q, Wang X. Green technology adoption in textiles and apparel supply chains with environmental taxes. International Journal of Production Research. 2020; 59(14):4157–4174. https://doi.org/10.1080/00207543.2020.1758354

[12] Yi Q, Li C, Tang Y, Chen X. Multi-objective parameter optimization of CNC machining for low carbon manufacturing. Journal of Cleaner Production. 2015; 95:256–264. https://doi.org/10.1016/J.JCLEPRO.2015.02.076

[13] Guo R, Lv S, Liao T, Xi F, Zhang J, Zuo X, Cao X, Feng Z, Zhang Y. Classifying green technologies for sustainable innovation and investment. Resources, Conservation and Recycling. 2020; 153:104580. https://doi.org/10.1016/J.RESCONREC.2019.104580

[14] Trapp CT, Kanbach DK. Green entrepreneurship and business models: Deriving green technology business model archetypes. Journal of Cleaner Production 2021; 297:126694. https://doi.org/10.1016/J.JCLEPRO.2021.126694

[15] Nasreen H, Adeel S, Yameen M, Amin N, Ozomay M, Qayyum MA. Green Application of Ultrasonic Waves for Extraction of Yellow Colorant from Haar Singhar and its Colouring Behaviour in Cotton Dyeing. Textile & Leather Review. 2023; 6:18-36. https://doi.org/10.31881/TLR.2022.67

[16] Khan MKR, Jintun S. Sustainability Issues of Various Denim Washing Methods. Textile & Leather Review. 2021; 4(2):96–110. https://doi.org/10.31881/TLR.2021.01

[17] Patwary S. Clothing and Textile Sustainability: Current State of Environmental Challenges and the Ways Forward. Textile & Leather Review. 2020; 3(3):158–173. https://doi.org/10.31881/TLR.2020.16

[18] Yang S, Song Y, Tong S. Sustainable retailing in the fashion industry: A systematic literature review. Sustainability. 2017; 9(7):1266. https://doi.org/10.3390/SU9071266

[19] Sinha P, Sharma M, Agrawal R. A systematic review and future research agenda for sustainable fashion in the apparel industry. Benchmarking: An International Journal. 2022. https://doi.org/10.1108/BIJ-02-2022-0142

[20] de Oliveira Neto GC, Correia JM, Silva PC, de Oliveira Sanches AG, Lucato WC. Cleaner Production in the textile industry and its relationship to sustainable development goals. Journal of cleaner production. 2019; 228:1514–1525. https://doi.org/10.1016/J.JCLEPRO.2019.04.334

[21] Chan HL, Shen B, Cai Y. Quick response strategy with cleaner technology in a supply chain: coordination and win-win situation analysis. International Journal of Production Research. 2018; 56(10):3397-3408. https://doi.org/10.1080/00207543.2016.1278283

[22] Islam MM, Perry P, Gill S. Mapping environmentally sustainable practices in textiles, apparel and fashion industries: a systematic literature review. Journal of Fashion Marketing and Management: An International Journal. 2021; 25(2):331–353. https://doi.org/10.1108/JFMM-07-2020-0130

[23] Cui C, Shaari N. Consumer in Sustainable Textiles: A Scientometric Review. Textile & Leather Review. 2023; 6:559–581. https://doi.org/10.31881/TLR.2023.084

[24] Bigliardi B, Bottani E. Green manufacturing practices in the fashion supply chain: lessons from Italian case studies. International Journal of Agile Systems and Management.2012; 5(1):4–28. https://doi.org/10.1504/IJASM.2012.045898

[25] Alay E, Duran K, Korlu A. A sample work on green manufacturing in textile industry. Sustainable Chemistry and pharmacy. 2016; 3:39–46. https://doi.org/10.1016/J.SCP.2016.03.001

[26] Todeschini BV, Cortimiglia MN, Callegaro-de-Menezes D, Ghezzi A. Innovative and sustainable business models in the fashion industry: Entrepreneurial drivers, opportunities, and challenges. Business horizons. 2017; 60(6):759–770. https://doi.org/10.1016/J.BUSHOR.2017.07.003

[27] Du Y, Li C. Implementing energy-saving and environmental-benign paradigm: machine tool remanufacturing by OEMs in China. Journal of Cleaner Production. 2014; 66:272–279. https://doi.org/10.1016/J.JCLEPRO.2013.10.033

[28] Chen L, Shen B, Wu X, Ding X. Development of a cost-effective energy and water management system for small and medium-sized manufacturers. Journal of Cleaner Production. 2017; 153:264–274. https://doi.org/10.1016/J.JCLEPRO.2017.03.165

[29] Saha K, Dey PK, Papagiannaki E. Implementing circular economy in the textile and clothing industry. Business Strategy and the Environment. 2021; 30(4):1497–1530. https://doi.org/10.1002/bse.2670

[30] McQuillan H. Digital 3D design as a tool for augmenting zero-waste fashion design practice. International Journal of Fashion Design, Technology and Education. 2020; 13(1):89–100. https://doi.org/10.1080/17543266.2020.1737248

[31] Carp B. 3D Printing in the Apparel Sector: How Environmentally Sustainable is it? Textile & Leather Review. 2020; 3(2):101–102. https://doi.org/10.31881/TLR.2020.PP02

[32] Sayem AS. Digital fashion innovations for the real world and metaverse. International Journal of Fashion Design, Technology and Education. 2022; 15(2):139–141. https://doi.org/10.1080/17543266.2022.2071139

[33] Dzhengiz T, Haukkala T, Sahimaa O. (Un) Sustainable transitions towards fast and ultra-fast fashion. Fashion and Textiles. 2023; 10(1):19. https://doi.org/10.1186/S40691-023-00337-9

[34] Luo Y, Song K, Ding X, Wu X. Environmental sustainability of textiles and apparel: A review of evaluation methods. Environmental Impact Assessment Review. 2021; 86:106497. https://doi.org/10.1016/J.EIAR.2020.106497

[35] Ahmad A, Madi Y, Abuhashesh M, Nusairat NM. The knowledge, attitude, and practice of the adoption of green fashion innovation. Journal of Open Innovation: Technology, Market, and Complexity. 2020; 6(4):107. https://doi.org/10.3390/JOITMC6040107

[36] Mazotto AM, de Ramos Silva J, de Brito LA, Rocha NU, de Souza Soares A. How can microbiology help to improve sustainability in the fashion industry? Environmental Technology & Innovation. 2021; 23:101760. https://doi.org/10.1016/J.ETI.2021.101760

[37] Gomes M, Soares G. A Review of Bacterial Pigments: Harnessing Nature's Colors for Functional Materials and Dyeing Processes. Textile & Leather Review. 2023; 6:167–190. https://doi.org/10.31881/TLR.2023.016

[38] Singh S, Rani J. Traditional Indian Textile Techniques Used to Upcycle and Recycle Textile Waste. Textile & Leather Review. 2021; 4:336–353. https://doi.org/10.31881/TLR.2021.29

[39] Choudhury AK. Sustainable chemical technologies for textile production. In: Muthu SS, editor. Sustainable Fibres and textiles. Cambridge, UK: Woodhead Publishing; 2017. p. 267-322. https://doi.org/10.1016/B978-0-08-102041-8.00010-X

[40] Islam MS, Ahmed S, Azady MAR. Sustainable technologies for textile production. In: Mondal MIH, editor. Fundamentals of Natural Fibres and Textiles. Cambridge, UK: Woodhead Publishing; 2021. p. 625–655. https://doi.org/10.1016/B978-0-12-821483-1.00017-6

[41] Mesdaghinia A, Mahvi AH, Nasseri S, Nodehi RN, Hadi M. A bibliometric analysis on the solid waste-related research from 1982 to 2013 in Iran. International Journal of Recycling of Organic Waste in Agriculture. 2015; 4:185–195. https://doi.org/10.1007/s40093-015-0098-y

[42] Bang NP, Ray S, Kumar S. Women in family business research—What we know and what we should know? Journal of Business Research. 2023; 164:113990. https://doi.org/10.1016/J.JBUSRES.2023.113990

[43] Singh A, Lim WM, Jha S, Kumar S, Ciasullo MV. The state of the art of strategic leadership. Journal of Business Research. 2023; 158:113676. https://doi.org/10.1016/J.JBUSRES.2023.113676

[44] Khandelwal U, Tripathi V, Gupta A. A bibliometric analysis of green branding research from 2000 to 2019. Vision. 2021. https://doi.org/10.1177/09722629211033916

[45] Bhukya R, Paul J. Social influence research in consumer behavior: What we learned and what we need to learn? –A hybrid systematic literature review. Journal of Business Research. 2023; 162:113870. https://doi.org/10.1016/J.JBUSRES.2023.113870

[46] Dutt I, Srivastav AL, Taneja A, Ali J. Research Progress of India in Waste Management at Global Level: A Bibliometric Evaluation. In: Kanwar VS, Sharma SK, Prakasam C, editors. Proceedings of International Conference on Innovative Technologies for Clean and Sustainable Development (ICITCSD – 2021). 14-15 October 2021; Himachal, India. India: Springer Cham; 2022. p. 595–601. Available from: https://doi.org/10.1007/978-3-030-93936-6_48

[47] Mukherjee D, Lim WM, Kumar S, Donthu N. Guidelines for advancing theory and practice through bibliometric research. Journal of Business Research. 2022; 148:101–115. https://doi.org/10.1016/J.JBUSRES.2022.04.042

[48] Donthu N, Kumar S, Mukherjee D, Pandey N, Lim WM. How to conduct a bibliometric analysis: An overview and guidelines. Journal of business research. 2021; 133:285–296. https://doi.org/10.1016/J.JBUSRES.2021.04.070

[49] Mongeon P, Paul-Hus A. The journal coverage of Web of Science and Scopus: a comparative analysis. Scientometrics. 2016; 106:213–228. https://doi.org/10.1007/s11192-015-1765-5

[50] Singh VK, Singh P, Karmakar M, Leta J, Mayr P. The journal coverage of Web of Science, Scopus and Dimensions: A comparative analysis. Scientometrics. 2021; 126:5113-5142. https://doi.org/10.1007/s11192-021-03948-5

[51] Niknejad N, Nazari B, Foroutani S, Hussin AR. A bibliometric analysis of green technologies applied to water and wastewater treatment. Environmental Science and Pollution Research. 2023; 30(28):71849-71863. https://doi.org/10.1007/s11356-022-18705-1

[52] Punj N, Ahmi A, Tanwar A, Rahim SA. Mapping the field of green manufacturing: A bibliometric review of the literature and research frontiers. Journal of Cleaner Production. 2023; 423:138729. https://doi.org/10.1016/j.jclepro.2023.138729

[53] Kraus S, Breier M, Lim WM, Dabić M, Kumar S, Kanbach D, Mukherjee D, Corvello V, Piñeiro-Chousa J, Liguori E, Palacios-Marqués D. Literature reviews as independent studies: guidelines for academic practice. Review of Managerial Science. 2022; 16(8):2577–2595. https://doi.org/10.1007/s11846-022-00588-8

[54] Abbate S, Centobelli P, Cerchione R, Nadeem SP, Riccio E. Sustainability trends and gaps in the textile, apparel and fashion industries. Environment, Development and Sustainability. 2023; 1–28. https://doi.org/10.1007/s10668-022-02887-2

[55] Page MJ, Moher D, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, Chou R. PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews. BMJ. 2021; 372. https://doi.org/10.1136/bmj.n160

[56] Kasavan S, Yusoff S, Guan NC, Zaman NSK, Fakri MFR. Global trends of textile waste research from 2005 to 2020 using bibliometric analysis. Environmental Science and Pollution Research. 2021; 28:44780-44794. https://doi.org/10.1007/s11356-021-15303-5

[57] Van Eck N, Waltman L. Software survey: VOSviewer, a computer program for bibliometric mapping. scientometrics. 2010; 84(2):523-538. https://doi.org/10.1007/s11192-009-0146-3

[58] García-Ávila F, Avilés-Añazco A, Cabello-Torres R, Guanuchi-Quito A, Cadme-Galabay M, Gutiérrez-Ortega H, et al. Application of ornamental plants in constructed wetlands for wastewater treatment: A scientometric analysis. Case Studies in Chemical and Environmental Engineering. 2023; 7:100307. https://doi.org/10.1016/J.CSCEE.2023.100307

[59] Moosa V, Shareefa M. Science mapping the most-cited publications on workplace learning. Journal of Workplace Learning. 2020; 32(4):259–272. https://doi.org/10.1108/JWL-10-2019-0119

[60] Chen C. Science Mapping: A Systematic Review of the Literature. Journal of Data and Information Science. 2017; 2(2):1-40. https://doi.org/10.1515/jdis-2017-0006

[61] Zupic I, Čater T. Bibliometric methods in management and organization. Organizational research methods. 2015; 18(3):429-472. https://doi.org/10.1177/1094428114562629

[62] Katz JS, Martin BR. What is research collaboration? Research policy. 1997; 26(1):1-18. https://doi.org/10.1016/S0048-7333(96)00917-1

[63] Dias C, Mendes L. Protected Designation of Origin (PDO), Protected Geographical Indication (PGI) and Traditional Speciality Guaranteed (TSG): A bibliometric analysis. Food Research International. 2018; 103:492–508. https://doi.org/10.1016/J.FOODRES.2017.09.059

[64] Han P, Shi J, Li X, Wang D, Shen S, Su X. International collaboration in LIS: Global trends and networks at the country and institution level. Scientometrics. 2014; 98:53–72. https://doi.org/10.1007/s11192-013-1146-x

[65] Shrivastava R, Mahajan P. Artificial intelligence research in India: a scientometric analysis. Science & Technology Libraries. 2016; 35(2):136-151. https://doi.org/10.1080/0194262X.2016.1181023

[66] Hallinger P, Suriyankietkaew S. Science mapping of the knowledge base on sustainable leadership, 1990–2018. Sustainability. 2018; 10(12):4846. https://doi.org/10.3390/SU10124846

[67] Fry LW, Egel E. Global leadership for sustainability. Sustainability. 2021; 13(11):6360. https://doi.org/10.3390/SU13116360

[68] Multala B, Wagner J, Wang Y. Durability standards and clothing libraries for strengthening sustainable clothing markets. Ecological Economics. 2022; 194:107358. https://doi.org/10.1016/j.ecolecon.2022.107358

[69] Perebynos A, Sepúlveda D, Ribeiro C. Study on textile waste generation in the undifferentiated municipal solid waste stream in Guimarães, Portugal. Waste Disposal & Sustainable Energy. 2023; 5:189–203. https://doi.org/10.1007/s42768-023-00137-3

[70] Song J, Dong X, Yang W, Xing J, Wang X. Environmental co-benefits of energy recovery from wastewater of typical industrial sectors from life cycle perspective: Regional potentials in China. Energy Conversion and Management. 2023; 293:117450. https://doi.org/10.1016/j.enconman.2023.117450

[71] Degenstein LM, McQueen RH, Krogman NT, McNeill LS. Integrating Product Stewardship into the Clothing and Textile Industry: Perspectives of New Zealand Stakeholders. Sustainability. 2023; 15(5):4250. https://doi.org/10.3390/su15054250

[72] Azanaw A, Birlie B, Teshome B, Jemberie M. Textile effluent treatment methods and eco-friendly resolution of textile wastewater. Case Studies in Chemical and Environmental Engineering. 2022; 6:100230. https://doi.org/10.1016/j.cscee.2022.100230

[73] Martínez-Martínez A, Cegarra-Navarro JG, Garcia-Perez A, De Valon T. Active listening to customers: eco-innovation through value co-creation in the textile industry. Journal of Knowledge Management. 2023; 27(7):1810-1829. https://doi.org/10.1108/JKM-04-2022-0309

[74] Yang Y, He W, Chen F, Wang L. Water footprint assessment of silk apparel in China. Journal of Cleaner Production. 2020; 260:121050. https://doi.org/10.1016/j.jclepro.2020.121050

[75] Subramanian K, Chopra SS, Cakin E, Li X, Lin CS. Environmental life cycle assessment of textile bio-recycling–valorizing cotton-polyester textile waste to pet fiber and glucose syrup. Resources, Conservation and Recycling. 2020; 161:104989. https://doi.org/10.1016/j.resconrec.2020.104989

[76] Shen B, Ding X, Chen L, Chan HL. Low carbon supply chain with energy consumption constraints: Case studies from China's textile industry and simple analytical model. Supply Chain Management: An International Journal. 2017; 22(3):258-269. https://doi.org/10.1108/SCM-05-2015-0197

[77] Xu X, He P, Xu H, Zhang Q. Supply chain coordination with green technology under cap-and-trade regulation. International Journal of Production Economics. 2017; 183:433–442. https://doi.org/10.1016/j.ijpe.2016.08.029

[78] Irick E, Eike RJ, Cho S, Kim M. Repurposing apparel: A guided process for sustainable design education. International Journal of Fashion Design, Technology and Education. 2020; 13(3):280-291. https://doi.org/10.1080/17543266.2020.1788652

[79] Kozlowski A, Searcy C, Bardecki M. The reDesign canvas: Fashion design as a tool for sustainability. Journal of cleaner production. 2018; 183:194–207. https://doi.org/10.1016/j.jclepro.2018.02.014

[80] Smith P, Baille J, McHattie LS. Sustainable Design Futures: An open design vision for the circular economy in fashion and textiles. The Design Journal. 2017; 20(Sup1):S1938–S1947. https://doi.org/10.1080/14606925.2017.1352712

[81] Shamsuzzaman M, Islam MM, Hasan HR, Khan AM, Sayem AS. Mapping environmental sustainability of knitted textile production facilities. Journal of Cleaner Production. 2023; 405:136900. https://doi.org/10.1016/j.jclepro.2023.136900

[82] Nayak R, George M, Haq IU, Pham HC. Sustainability benefits of RFID technology in Vietnamese fashion supply chain. Cleaner Logistics and Supply Chain. 2022; 5:100086. https://doi.org/10.1016/j.clscn.2022.100086

[83] Ashby A. Developing closed loop supply chains for environmental sustainability: Insights from a UK clothing case study. Journal of Manufacturing Technology Management. 2018; 29(4):699-722. https://doi.org/10.1108/JMTM-12-2016-0175

[84] Staicu D, Pop O. Mapping the interactions between the stakeholders of the circular economy ecosystem applied to the textile and apparel sector in Romania. Management & Marketing. Challenges for the Knowledge Society. 2018; 13(4):1190-1209. https://doi.org/10.2478/mmcks-2018-0031

[85] Vehmas K, Raudaskoski A, Heikkilä P, Harlin A, Mensonen A. Consumer attitudes and communication in circular fashion. Journal of Fashion Marketing and Management: An International Journal. 2018; 22(3):286-300. https://doi.org/10.1108/JFMM-08-2017-0079

[86] Shen B, Li Q, Dong C, Perry P. Sustainability issues in textile and apparel supply chains. Sustainability. 2017; 9(9):1592. https://doi.org/10.3390/su9091592

[87] Bukhari MA, Carrasco-Gallego R, Ponce-Cueto E. Developing a national programme for textiles and clothing recovery. Waste Management & Research. 2018; 36(4):321-331. https://doi.org/10.1177/0734242X18759190