A DECADE OF STUDIES ON SUSTAINABLE TEXTILES: TRENDS AND FUTURE EDUCATIONAL DIRECTIONS

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Abstract. Sustainability in the textile industry has become a critical issue due to environmental degradation, resource depletion, and pollution linked to fast fashion and linear production models. This study examines the intellectual development of sustainable textile research from 2015 to June 2024 and its implications for education. A bibliometric analysis was conducted on 1,286 Scopus-indexed articles, of which 698 met the inclusion criteria after semantic filtering. Performance analysis and science mapping identified publication trends, thematic clusters, and collaboration networks. Five dominant research areas emerged: sustainability integration, waste management, material innovation, Industry 4.0 technologies, and socio-cultural literacy. The geographic distribution of research shifted toward emerging economies, particularly India and China, reflecting the concentration of textile production and policy emphasis on circularity. Findings suggest that sustainable textile education must integrate circular economy principles, digital and data-driven design skills, environmental ethics, and socio-cultural awareness. Embedding these dimensions in curricula can equip future textile professionals to innovate across ecological, technological, and cultural domains.
Keywords: *eco-innovation, circular economy, material innovation, industry 4.0, textile education*

Introduction

The educational dimension of sustainable textiles has become increasingly significant, considering the environmental challenges inherent in the textile industry. As fast fashion and linear production models contribute to escalating environmental degradation, resource depletion, and pollution, sustainability has evolved from a policy agenda item to a pedagogical necessity. Between 2015 and 2025, the field experienced marked growth, prompting a need to assess its intellectual evolution critically. Researchers have examined how sustainability concepts are embedded in textile curricula and design, with scholars such as Sidian et al. (2023) emphasising the vital role of universities in translating sustainability into educational processes that shape future industry norms. Educational institutions not only generate knowledge but also foster behavioural and ideological shifts toward environmentally responsible design. Similarly, Sarker and Bartók (2023) advocate for academic–industry networks to accelerate the development of green technologies in the textile sector, reinforcing the value of robust cross-sector collaboration.

Despite the expanding body of literature on sustainable textiles, there has been a limited systematic effort to map the intellectual history of the field in relation to education. Existing reviews often concentrate on specific technical aspects, such as wastewater treatment or wearable technologies, or on consumer-related perspectives, such as sustainability literacy, without integrating these insights into a comprehensive

bibliometric synthesis. More importantly, none of the prior studies connect bibliometric evidence with actionable strategies for curriculum development. This disconnect leaves educators and policymakers without a robust, evidence-based framework for embedding sustainability principles into textile education. This study addresses the identified gap through a quantitative bibliometric analysis designed to: examine temporal publication trends in sustainable textile research from 2015 to June 2025 to capture patterns of academic and industrial interest; analyse the geographic and institutional distribution of research output with particular attention to emerging centres of knowledge in textile-producing economies; identify prevailing thematic clusters and intellectual structures through co-occurrence and co-citation analyses; and translate these bibliometric findings into strategic curriculum innovation directions, with emphasis on the circular economy, digital integration, environmental ethics, and socio-cultural literacy.

This study is the first to link a decade-long bibliometric synthesis of sustainable textiles with concrete recommendations for curriculum development. By bridging research trends with educational reform, it offers a unique evidence-based pathway for preparing future textile professionals to address complex sustainability challenges in design, production, and governance. Guided by these objectives, this study seeks to answer the following questions: (RQ1): What are the temporal publication trends in sustainable textile research between 2015 and June 2025, and how do they reflect patterns of academic and industrial interest? (RQ2): How is sustainable textile research distributed geographically and institutionally, and which emerging economies are leading knowledge production? (RQ3): What are the prevailing thematic clusters and intellectual structures revealed through co-occurrence and co-citation analyses of the field? (RQ4): How can these bibliometric findings be translated into strategic directions for curriculum innovation in sustainable textile education?

Literature review

Current trends in sustainable textile research

The sustainability of the textile world consists of various aspects, such as sourcing materials, production methods, and the disposal of textiles, which all depend on the important topic of sustainability in the textile sector. The bibliometric analysis conducted by Halepoto et al. (2022) outlines the modern state of the field of textile wastewater treatment (three most common approaches have been selected to examine, namely adsorption, chemical oxidation, and biological techniques). Although the paper presents an in-depth analysis of pollution control technologies, it does not give enough weight to the sustainability aspect of the future of textile education in terms of applying a circular economy, developing bio-based materials, and educating future textile practitioners. The identified gap in the research of Halepoto et al. is deemed crucial. However, industrial wastewater treatment is doubtlessly a necessary process; the discussion should go further and include sustainable methods applicable in all life cycle aspects of the textile. Dumitrescu et al. (2022) examine the possibility of using the biomass in orange waste films and transforming it into bio-based textiles. The new innovative technology not only unites material science and sustainable design but also points to the possibility of using alternative raw materials to reduce the environmental impacts of traditional textile production. According to such studies, there is a need to learn about the integration of sustainable sources of raw materials and sustainable production-related processes in textile education, which is currently underexplored in

the bibliometric analysis conducted by Halepoto et al. This suggests that while technical innovations in waste treatment and bio-based material production are advancing, their integration into educational frameworks remains limited. However, no studies have systematically connected these technological developments with curriculum design to prepare graduates for sustainable textile practice.

The growing importance of sustainability in the textile sector

The trend of sustainability in the textile industry covers urgent problems such as environmental pollution and social problems of fast fashion. Circular economy (CE) turns out to be a vital scope that requires additional investigation. Chen et al. also underline that the textile industry faces many problems with CE implementation because of the high competition and the necessity to be more sustainable (Chen et al., 2021). Additionally, Hossain et al. highlight the lack of knowledge about microplastics produced during production, supporting the idea of overall approaches to reducing pollution (Hossain et al., 2025). The study by Zaman and Kozina (2021) underscores the importance of teaching textile literacy in education, as it addresses gaps in consumer knowledge that can foster responsible consumption. Still, the successful implementation of sustainability into textile education is understudied, especially when it comes to the upcycling processes in textile design education (Sidian et al., 2023). Thus, future research should focus on closing educational gaps to build an informed consumer base and enable sustainable textile production and consumption (Abbate et al., 2023; Al-Nuaimi and Al-Ghamdi, 2022; Chen et al., 2021). This suggests that sustainability literacy, circular-economy principles, and pollution awareness are essential for equipping future textile professionals (Al-Nuaimi and Al-Ghamdi, 2022; Chen et al., 2021). However, to our knowledge, no study has yet combined these strands into a cohesive pedagogical model and grounded it in bibliometric evidence (Ramírez-Escamilla et al., 2024).

Limitations of previous reviews

Previous reviews on sustainable textiles often exhibit limitations, particularly in their approach to mapping the intellectual structure and employing network-based bibliometric analyses. Most existing studies, such as those by Dulal et al., focus on specific aspects like wearable technologies without providing a holistic view of the entire field of sustainable textiles (Dulal et al., 2022). Moreover, many reviews, including the one by Cui and Shaari (2023), concentrate on consumer behavior toward sustainability but lack a comprehensive bibliometric analysis that considers co-authorship and co-citation networks, which could elucidate the relationships between different research streams (Cui and Shaari, 2023). This gap emphasizes the need for a more integrative analysis to provide a clearer understanding of sustainable textiles and their implications for future textile education, as highlighted in Sidian et al.'s research on integrating sustainable design practices into textile courses (Sidian et al., 2023). Therefore, a detailed bibliometric analysis could significantly enhance the academic dialogue in sustainable textile education and practice. This suggests that while thematic and sector-specific insights exist, they are fragmented and lack network-level analysis. However, no studies have provided a holistic bibliometric mapping of sustainable textiles that directly informs curriculum development priorities.

Need for a quantitative meta-synthesis

The current study of sustainable textiles reveals significant gaps in the application of quantitative meta-synthesis in the education sector. Although some bibliometric studies have already successfully applied such tools as VOSviewer to monitor the themes related to textile waste management and sustainability practices (Judijanto and Pahrijal, 2024), there is a gap that should be filled with similar systematic research to assess the educational aspects of textile sustainability. The interventions, like experiential learning in textile design, also have promise but have not been tested quantitatively (Ma et al., 2022). Also, although the ideas of environmental protection are becoming more ingrained in the educational process of textile workers (Pu et al., 2021), the comparison of teaching structures and research output is underrepresented. It requires a profound bibliometric analysis of the evolutionary indicators of sustainability education in textiles to highlight and fill these educational gaps and enhance the development of the curriculum in the future. This suggests that bibliometric methods can produce valuable insights for aligning research output with educational needs. However, no studies have systematically employed quantitative bibliometric meta-synthesis to bridge sustainable textile research with targeted curriculum reform.

Materials and Methods

The study was a quantitative bibliometric analysis, which aimed to map the intellectual, thematic, and collaborative networks of sustainable textile research between 2015 and 2025, and specifically to draw strategic implications for textile education. The data were extracted using the Scopus database because it is a resource of peer-reviewed literature in science, engineering, and social sciences. Scopus was selected because it offers extensive coverage of peer-reviewed journals across science, engineering, and social sciences, and provides well-structured bibliographic metadata compatible with bibliometric tools such as Bibliometrix and VOSviewer. Compared to Web of Science (WoS), Scopus indexes a broader range of journals in engineering and applied sciences, which are central to textile sustainability. Meanwhile, newer platforms such as Dimensions and Lens.org have rapidly expanding coverage, but they include grey literature and preprints that are not always peer-reviewed, raising concerns about data consistency. While reliance on a single database introduces potential coverage bias — as Scopus may underrepresent regional or non-English journals this limitation was mitigated by focusing on mainstream, peer-reviewed literature most relevant to curriculum and policy translation. Nevertheless, future studies could strengthen robustness by performing cross-database comparisons to capture overlooked perspectives from WoS, PubMed, or Dimensions. This search was conducted in June 2025, and it started with 1,096 records.

To ensure the reproducibility of bibliometric studies, it is essential to provide the exact search string, including Boolean operators, truncations, and field tags. In this study, the dataset was retrieved from Scopus using the following query: TITLE-ABS-KEY(“sustainable textile” OR “eco-friendly textile” OR “green textile” OR “circular textile” OR “sustainable fabric”). This search string was deliberately broad to capture diverse terminology commonly associated with sustainability in textile and apparel research. By applying this query to the Title, Abstract, and Keywords fields, the search reduced the likelihood of overlooking relevant articles that might not use standardized terminology in their titles alone. The inclusion of synonyms such as “eco-friendly” and

"green textile" was particularly important to avoid linguistic bias in the retrieved corpus. For transparency and replicability, the complete search query and filtering steps are included in the Appendix, allowing future researchers to replicate or refine the dataset according to their own scope. Although the research aims to examine sustainable textile literature published between 2015 and 2025, it should be noted that the data were obtained in June 2025, implying that only articles that were available in Scopus to date were used. Since bibliometric data are dynamic and updated regularly, the findings provide a time-limited view of the field, rather than a comprehensive representation of its development throughout the entire year 2025.

The present research might be followed in the future by adding publications indexed after June 2025 to obtain a more detailed image of the developments in the second part of the year. To filter the dataset, the TF-IDF (Term Frequency Inverse Document Frequency) cosine-similarity method of vector-space semantic filtering was applied using R. The Title and Abstract of each document were inserted into a TF-IDF term–document matrix, and the query term sustainable textiles was placed into the same semantic space. Similarity scores were computed between each document and the query vector, and records with a score below 0.01 were removed. The 0.01 threshold was selected as an optimal trade-off between recall and precision: higher thresholds (e.g., 0.02) risked excluding relevant studies that used diverse terminology, while lower thresholds (e.g., 0.005) admitted excessive noise from tangentially related works. Sensitivity checks confirmed that at 0.02, approximately 9% more records would be excluded, often interdisciplinary papers using alternative phrasing, whereas at 0.005, the dataset increased by nearly 12% but included marginally relevant studies. Similar thresholding strategies have been applied in other bibliometric studies (Judijanto and Pahrijal, 2024; Sarker and Bartók, 2023). Thus, the 0.01 value ensured thematic inclusivity while maintaining dataset integrity and analytical robustness. This automated semantic exclusion procedure helped eliminate records that were not contextually relevant to the sustainability-textile nexus. After this, the inclusion criteria further reduced the data set to: (1) Journal articles reviewed by peers written until June 2025; (2) English language publications; (3) Studies that directly touched upon the sustainability of the textile and apparel industries, namely, in the aspects of design, circularity, life cycle assessment, environmental innovation, or educational impact.

Articles like conference proceedings, editorials, duplicates, and articles that were considered irrelevant were excluded, and a final dataset of 698 articles was obtained. The cleaned data was exported in a CSV file including full bibliographic metadata. Data cleaning and standardization were performed in R Studio using the convert2df() and biblioshiny() functions of the Bibliometrix R package to ensure data consistency and prepare it for analysis. This was to standardize author names, institutional affiliations, and taxonomies of keywords, and to deal with typical irregularities, such as variant spelling and formatting. After that, the combination of performance analysis and science mapping was employed. Co-authorship, co-citation, and keyword co-occurrence networks were built with VOSviewer (v1.6.19) using a fractional counting (minimum counter, e.g., five co-occurrences of keywords). Publication trends, citation impact, source prominence, and thematic maps are the outputs of an analytical tool that was generated by the Bibliometrix R package, specifically the Biblioshiny interface. Keywords were clustered into thematic maps or thematic clusters, which included circular economy, waste recovery, digital integration, and environmental literacy, and cross-validated with co-citation clusters. Also, the Co-occurrences and co-citations

network by the author's keywords was designed to show the connection between authors, keywords, and sources. These triangulated bibliometric maps provided a comprehensive meta-level overview of the current state of sustainable textile research, offering curricular guidelines to future-proof textile education in line with the demands of sustainability.

As noted, specific methodological descriptions, particularly the decision to choose Scopus and the lengthy explanation of the TF-IDF threshold, were introduced redundantly. These parts may be simplified in such a way that the clarity of the methodology is maintained without disrupting the flow of the paper in general. In addition, it is suggested that the educational interpretation of bibliometric results should not only be incorporated in the Discussion section but also in the Results. In this manner, the relationship between research and education becomes more apparent in the story, rather than being buried in the final analysis.

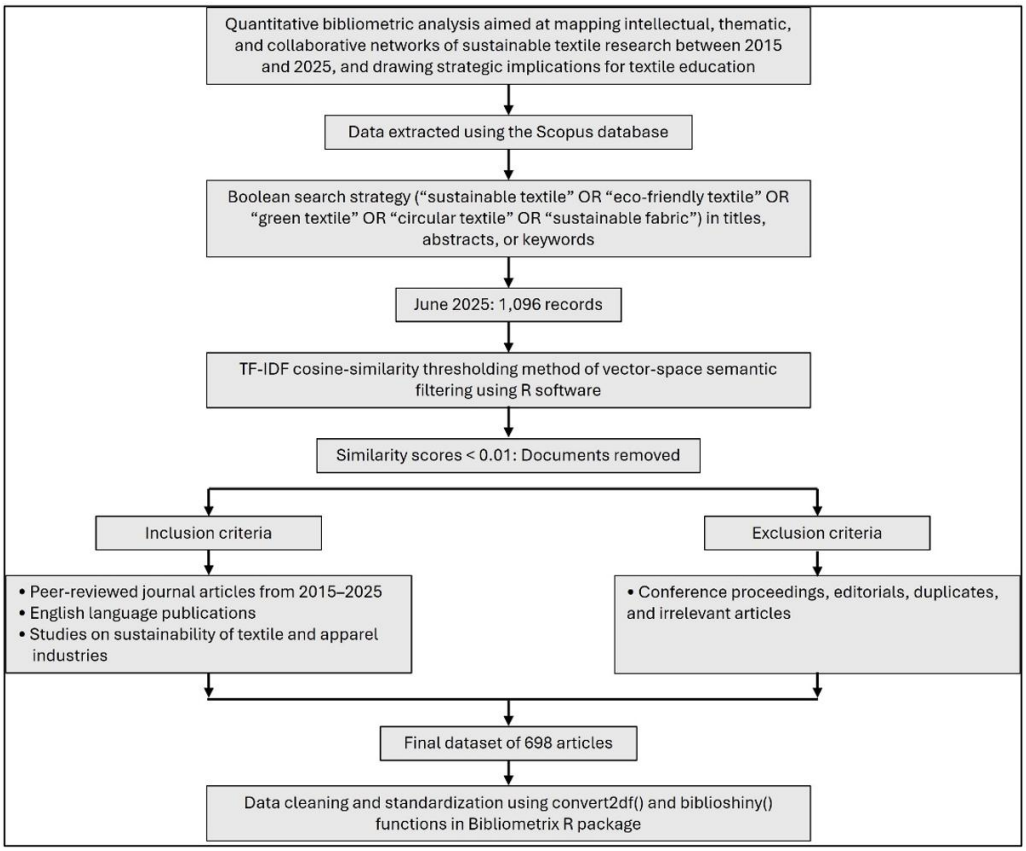

Figure 1. *Data selection and analysis pipeline for quantitative bibliometric study.*

Results and Discussion

Annual publication trends

Figure 2 portrays the trends in the number of publications in sustainable textiles in 2015-2025, revealing that the number of articles rose considerably and at a rapid rate over the past five years. After a humble start of 11 publications in 2015, the volume has grown steadily with a significant spurt in 2019 (42 publications) and 2020 (43). This

pace continued to grow, reaching 73 in 2021, 82 in 2022, and 152 in June 2024. The fact that interest fell only a little to 139 in June 2025 indicates that it remains high. This pattern indicated the increasing interest of researchers in the problem of sustainability in the textile industry in terms of world policy changes, technological progress, and reforms in education. The sharp increase after 2020 is likely linked to the growing debate on climate action and circular economies. In future teaching in textiles, this will translate into the rising importance of sustainability issues in the development of both curricula and academic research. It also indicates that learning institutions will have to respond to a rapidly changing body of knowledge and focus on eco-innovation, systems thinking, and cross-disciplinary training of future textile professionals.

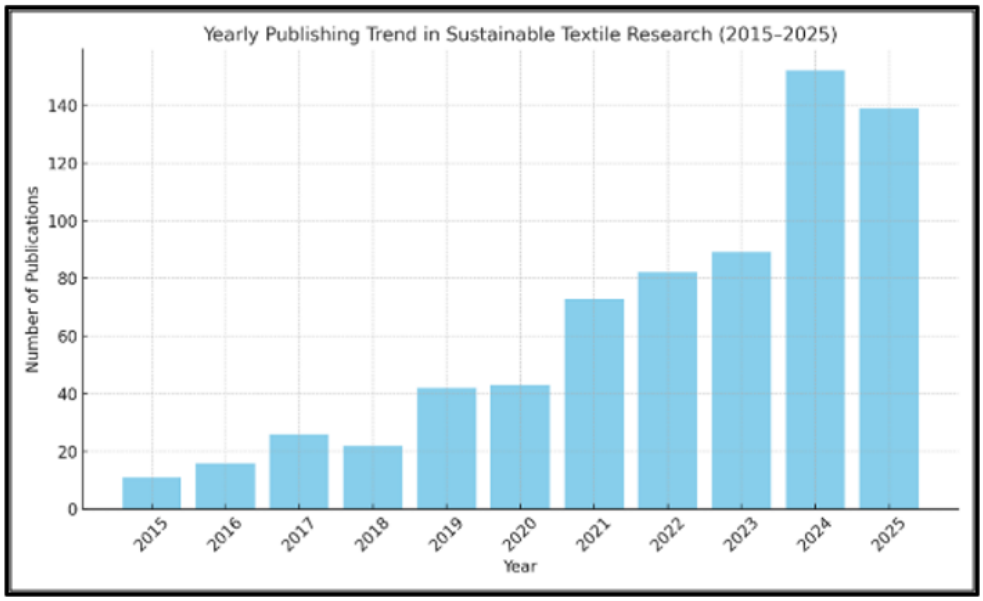

Figure 2. *Annual publication trends in sustainable textile research (2015–2025).*

The bibliometric snapshot in *Figure 3* indicates that the studies on sustainability-oriented textiles are being led by researchers and institutions in the fast-industrializing economies in Asia, with India, China, and Pakistan contributing more than half of the overall production. On the author level, individual productivity is relatively low, with Adeel in first position with eight papers, followed by a tightly knit cluster of seven, but with the total effect enhanced by association with teaching-focused Schools that cut across fashion, textiles, engineering, business, and design, and so the topic is likely to be interdisciplinary. Surprisingly, the highest-ranked School of Fashion and Textiles (nine articles) seems to be a loose network of different campuses or satellite institutes, rather than a single powerhouse lab, and the second highest-ranked School of Business emphasizes the increasing managerial and supply-chain perspective of circular-economy issues. The dominance of countries is even more concentrated: the 203 papers published by India surpass by far the strong 170 of China, in part due to its enormous textile industry and a policy push toward recycling and circularity; and the United States (128) stands out prominently even though it has no author in the top ten, an indication of a broader but less individually productive researcher base. Below position five, there will be a second level of countries (Pakistan, Germany, Bangladesh, Australia, Italy, Brazil) with a similar number of articles, about 55-70, enough to have a viable national research

community but small enough that a focused group (e.g., Amity Institute of Biotechnology) can have a material impact on its position. On the whole, the trend showed an area in which institutional branding is generic, author leadership diffuse, and geopolitical weight is moving towards emerging producer countries, which supports the thesis that sustainable-textile scholarship follows the distribution of manufacturing risk and opportunity in the world.

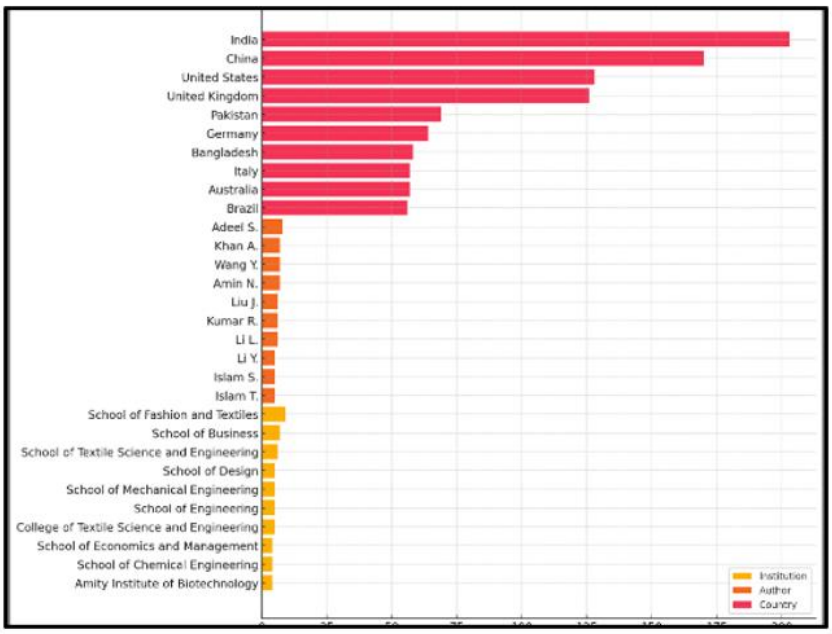

Figure 3. *Leading authors, affiliations, and countries in sustainable textile research (2015–2025).*

Co-occurrences and co-citations network by the author's keywords

The co-occurrence map of keywords of the authors showed five thematic clusters, which are the key areas of concern in the discourse of sustainable textiles. *Figure 4* showed the red cluster, with cotton, yarn, dyeing, weaving, and natural dye in its core, which is evidence of the further significance of material science and the traditional production process. This cluster suggests that the direction of research could involve reformulating textile manufacture by incorporating bio-based and environmentally friendly materials into established processes. On the contrary, the blue cluster combines keywords such as effluents, bioremediation, water pollution, and public health, which are relevant in environmental science as potential solutions to pollution caused by the textile industry. These researchers are concerned with the after-effects and clean-up technologies in the post-production period and have concentrated on sustainability as an ecological necessity. The green cluster is policy and behavior-oriented, and its keywords include consumer behavior, government, business, and the textile and apparel industry. This showed that there is a developing understanding that sustainable change needs to involve changes in market structures, regulatory frameworks, and general awareness. In the meantime, the yellow cluster embraces new technological solutions and concepts, such as artificial intelligence, machine learning, landfill, and waste management, indicating possibilities for innovations in the circular economy and the application of predictive technologies to streamline resource flows. Finally, the purple

cluster, which includes such terms as fashion, COVID-19, and fabric face masks, reflects temporary but influential changes in textile research, focusing on flexibility, quick response to design challenges, and durability in the face of global disturbances.

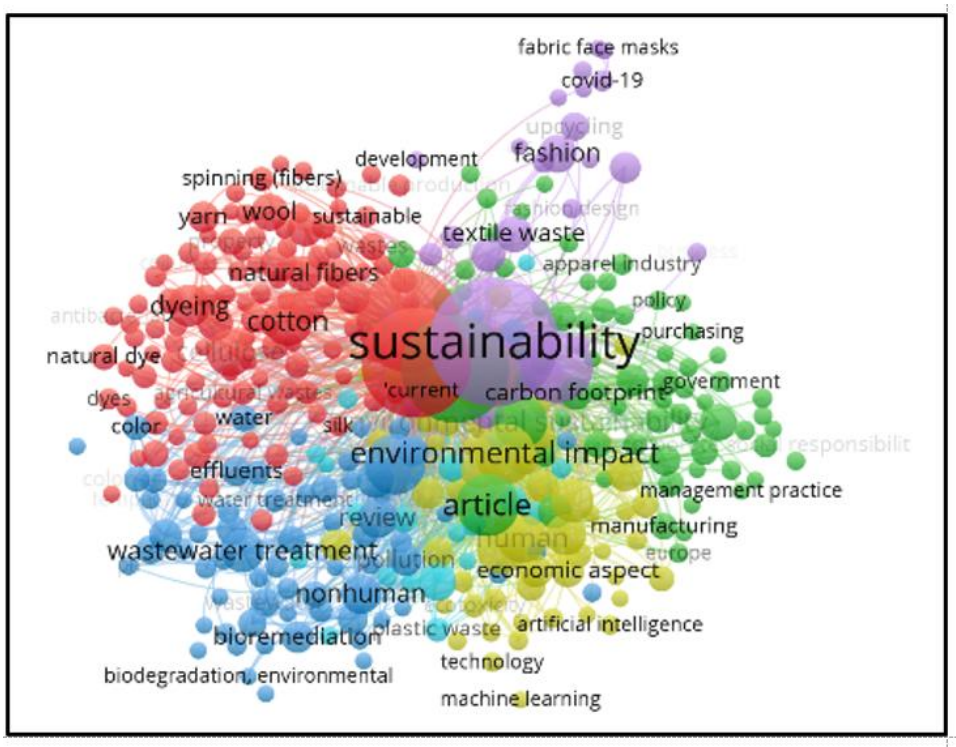

Figure 4. *Co-occurrence map of authors' keywords in sustainable textile research (2015–2025).*

The clusters have both urgent and broad implications for textile education. The red and blue clusters encourage curriculum designers to incorporate the old ways of doing things with new information about green chemistry, biodegradability, and water ethics, to give students the ability to become innovators in existing systems. The green cluster highlights the need to introduce educational modules with socio-economic content, focusing on sustainability literacy, policy analysis, and ethical business strategy as central issues in fashion and textile schools. The yellow cluster refers to a future-looking transformation to digital fluency; design training should now incorporate data science, machine learning, and life cycle assessment platforms into its coursework, as per the expectations of Industry 4.0. Lastly, the purple cluster is a response to the need to educate students on how to react quickly to the changes within the market and society, which implies that the textile education should promote agility, crisis response, and speculative design thinking. Taken together, these clusters highlight the need to develop a transdisciplinary, digitally enabled, and ethically sound model of textile education that can produce graduates who are ready to innovate within and across ecosystems, including the fiber and fashion systems, with technical competence and awareness of society.

Figure 5 showed co-citation analysis indicates that the most cited publication years in the sustainability and textiles literature are (2021) with 80, followed by (2022) with 61, (2020) with 57, (2018) with 51, (2017) with 49, (2019) with 43, and (2023) with 39 citation respectively, whereas the foundational years such as (2015), (2013) and (20

This implies that the intellectual centre of the discipline is not only new but also cumulative: accumulating and synthesizing modern knowledge with mid-2010s background research. In addition, occasional citations to previous studies between 2006 and 2012 demonstrate the persistence of classic works that contributed to the development of critical discourses on sustainable development, the circular economy, and green innovation in the field of textile studies. These inclinations not only suggest the emergence of research interests but also the constant enhancement of the principal theoretical and practical contributions to the discipline.

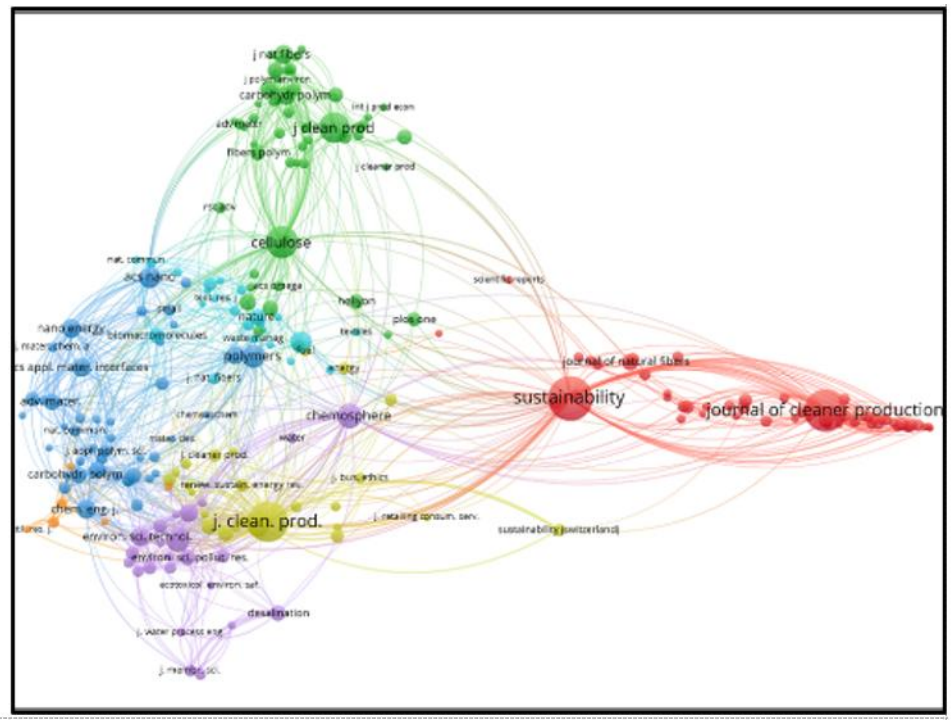

Figure 5. *Co-citation network of cited sources in sustainable textile research (2015–2025).*

To be more specific, the co-citation network visualization, which has already been separated into five most important clusters, allows for a multidimensional view of the scholarly ecosystem. The most common in the red cluster, which grounds the literature on the practice of sustainable development, environmental management, and ethically responsible textile supply chains, are the Journal of Cleaner Production, Sustainability, and the Journal of Natural Fibers. The high frequency of citations in this cluster indicates its centrality in the sphere of theory and application, specifically in the context of life cycle assessments and circularity. The green cluster, centered on Cellulose, Polymer, and Carbohydrate Polymers, is concerned with material developments in the area of biopolymers and renewable fibers, which is the chemistry and engineering-based side of the sustainability of textiles. The blue cluster is based on journals like Nature, ACS Nano, and Advanced Materials, and it is a technologically intensive sphere, which is concerned with nanofibers, smart textiles, and energy-efficient materials. In the yellow cluster, there are such journals as Chemosphere, Environmental Science and Pollution Research, Journal of Business Ethics that report on eco-toxicology, pollution remediation, and corporate responsibility, and integrate environmental science and sustainability governance.

The purple group provides niche yet valuable information to engineering water-related documents, including desalination, the Journal of Membrane Science, and the textile industry's water footprint and purification technology. In the future, the combination of these co-citation clusters indicates that there are major implications that textile education needs to address in the future. This interdisciplinary overlap needs to be increasingly reflected in curricula - environmental ethics, circular design principles, polymer science, nanotechnology, and systems thinking need to be integrated. The future of textile education will need hybrid learning models that combine lab-based experimentation with data-driven sustainability models and collaborative project-based learning between academia and industry. With sustainability further transforming the content and pedagogy of textile design, teachers will have to match the instructional practices with the emerging technologies, co-citation-based knowledge structuring, and inter-sectoral innovations. This change will equip graduates to design with responsibility, but also to be a part of systemic change in the value chain of textiles.

Thematic structure of keyword occurrence

The thematic map presents a multilayered and complex framework of sustainable textile studies, offering direct guidance for the future of textile research. The cluster of sustainability, sustainable development, and the textile industry is situated in the Basic Themes quadrant, which implies that the concepts are in the centre of the field (high centrality). However, they are not profound as independent areas of research (low density). This indicates their fundamental appearance in most of the studies, which is also reflected in the frequent appearance of terms like sustainability, textile design, and environmental impact in the dataset, yet also points to a necessity of more profound curricular integration than a superficial discourse. The most actively developed and strategically located themes in the field are offered in the Motor Themes quadrant, which includes recycling, environmental impact, and article. This is testified to in terms of such keywords as the fiber recovery, chemical recycling, life cycle assessment, and pollution prevention, which are all signs of emerging research on closed-loop systems and ecological measures. These are the spheres that must inform the further creation of textile programmes, which strive towards the consideration of the circular economy, eco-efficiency, and material traceability.

The Niche Themes quadrant that includes such concepts as textile, wastewater treatment, and nonhuman would suggest extremely narrow subfields, yet dense, which is also in line with most of the indexed terms present in the data, such as bioremediation, electrocoagulation, and toxicology. These new crossroads are indications that there is a need to have technical modules in high-end filtration systems, sustainable wet processing, and environmental biotechnology. Comparatively, the Emerging or Declining Themes quadrant, which is in the shape of cotton, cellulose, and dyeing, harbors the historically robust yet immature themes, perhaps due to a shift to innovation instead of convention. However, they are found in such keywords used by authors as natural dye, cotton fabric, and bio-based textiles, which means that they can be renewed via sustainable redesign. This is educationally necessitated by the need to have a curriculum that re-contextualizes the old knowledge of textiles in sustainability aspects, relating the old methods to green chemistry and biofabrication. The aggregate impact of the thematic structure is that the education in textiles must become an interdisciplinary, systems-based, and technology-related area. The curricula should focus not only on general literacy in sustainability but also on specialist training in

waste recovery, lifecycle analysis, and environmentally conscious design. This training should be supported by real-time data analysis and team-based research in material science, environmental policy, and AI-based manufacturing (*Figure 6*).

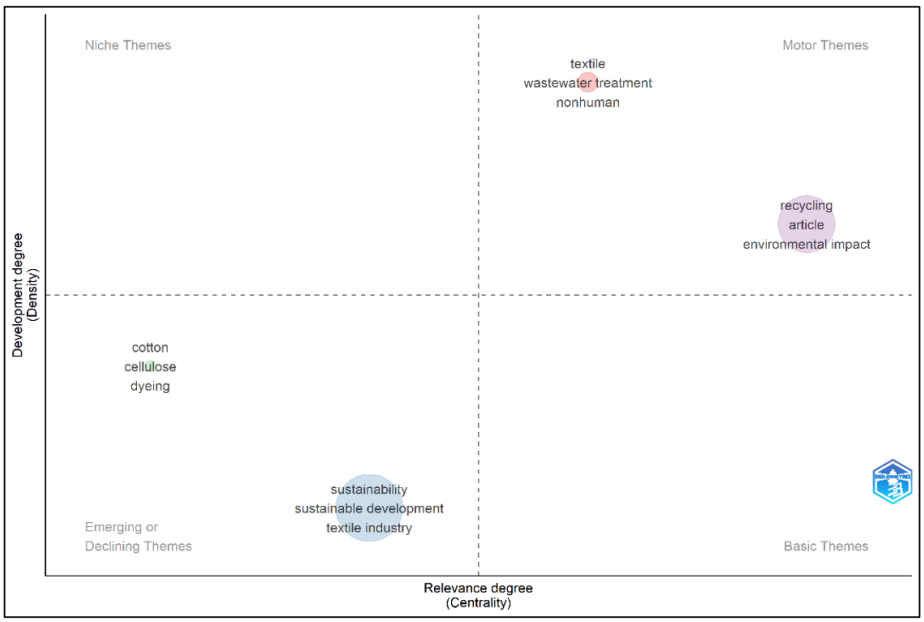

Figure 6. *Thematic map of keyword occurrence in Sustainable Textile Research (2015–2025).*

Building on the bibliometric mapping of clusters, *Table 1* presents a framework that directly links the intellectual structure of sustainable textile research to curriculum implications and pedagogical strategies. This framework represents the practical translation of bibliometric evidence into educational reform.

Table 1*. Thematic clusters of sustainable textile research and their curriculum implications.*

Cluster (Research Focus)	Curriculum Implication	Pedagogical Strategy
Red Cluster – Traditional processes & materials (cotton, yarn, natural dyes, weaving)	Integrate traditional knowledge with sustainable redesign (e.g., green chemistry, eco-dyeing, bio-based fabrics)	Studio-based projects blending heritage craft with modern sustainability science
Blue Cluster – Environmental remediation (effluents, bioremediation, water pollution, public health)	Teach environmental ethics, wastewater management, and water footprint analysis.	Lab modules on sustainable wet processing; case-based learning on pollution control
Green Cluster – Policy & behavior (consumer behavior, governance, industry regulation)	Develop sustainability literacy, policy analysis, and ethical business frameworks	Interdisciplinary courses combining fashion, business, and environmental policy
Yellow Cluster – Industry 4.0 technologies (AI, ML, waste management, circularity)	Equip students with digital fluency for circular design and predictive sustainability.	Training in AI/data analytics for design; integration of lifecycle analysis platforms
Purple Cluster – Societal responsiveness (COVID-19, masks, adaptive textiles)	Promote agility, crisis response, and speculative design	Project-based learning on responsive design, futures thinking, and social innovation

Red cluster (traditional processes and materials)

The red cluster emphasizes traditional processes such as cotton, yarn, weaving, and natural dyes, which remain central to textile sustainability debates. For education, this cluster implies the need to integrate traditional knowledge with sustainable redesign through green chemistry, eco-dyeing, and the use of bio-based fabrics. Pedagogically,

this can be addressed through studio-based projects that blend heritage craft with modern sustainability science, encouraging students to connect traditional practices with ecological innovation.

Blue cluster (environmental remediation)

The blue cluster reflects concerns with effluents, bioremediation, water pollution, and public health. Its curricular implication is the importance of teaching environmental ethics, wastewater management, and water footprint analysis. Appropriate pedagogical strategies include laboratory modules on sustainable wet processing techniques as well as case-based learning approaches that expose students to real-world pollution control and remediation challenges.

Green cluster (policy and behavior)

The green cluster highlights governance, consumer behavior, and industry regulation, pointing to the socio-economic dimensions of sustainable textiles. This suggests a curricular emphasis on developing sustainability literacy, policy analysis, and ethical business frameworks. Interdisciplinary courses that combine fashion and textiles with business studies, economics, and environmental policy are particularly well-suited to deliver these competencies.

Yellow cluster (industry 4.0 technologies)

The yellow cluster captures emerging technologies such as artificial intelligence, machine learning, and predictive waste management systems within circular economy models. Its educational implication is the urgent need to equip students with digital fluency to apply advanced tools for circular design and predictive sustainability. Pedagogically, this requires training in AI and data analytics for design, as well as the integration of lifecycle analysis platforms into coursework, preparing graduates for technology-driven sustainability solutions.

Purple cluster (societal responsiveness)

The purple cluster underscores the role of textiles in responding to crises such as COVID-19, particularly through adaptive and socially responsive design. This implies that curricula must promote agility, crisis preparedness, and speculative design thinking as essential competencies for future professionals. Project-based learning approaches focused on responsive design, futures thinking, and social innovation are key strategies for equipping students to innovate rapidly in the face of societal disruptions. The study might be enhanced by placing a conceptual table in which bibliometric clusters are associated with curriculum competencies and teaching methods. This kind of structure would bring the manuscript to a higher level of descriptive mapping and make it a theory-building contribution. Besides that, each thematic cluster should be accompanied by an explicit discussion of pedagogical innovations, i.e., experiential learning, industry-academia collaborations, and design thinking. Through these strategies, the study would not just bring out what is coming out in knowledge, but also how it can be successfully applied in the classroom and curriculum practice. Even though this research paper provides a bibliometric review of the existing literature on sustainable textiles and their educational prospects, several limitations should be acknowledged.

The period from 2015 to June 2025 was chosen to provide a decade-long overview while capturing the most recent scholarship available at the time of data extraction. Using June 2025 as a fixed cut-off ensures a stable and reproducible dataset, offering a transparent snapshot of the field that future studies can extend with later publications. The use of Scopus alone could have created coverage bias through a lack of representation of social sciences, humanities, and non-indexed local journals, and the use of English-language, peer-reviewed articles only barred possibly relevant conference papers, books, reports, and non-English publications. Citation-based metrics, including citation count and h-index, are measures of visibility and not quality and may be affected by the size of the field, age of publications, and self-citation. The TF-IDF cosine similarity threshold (0.01) increased the precision of the data. Still, it might have filtered out conceptually relevant studies with different terms, and the findings might be different with different thresholds. Also, since the data was collected in June 2024, the results present a static image but not a constantly changing image of the profession. Lastly, bibliometric analysis only reflects the structural trends but not the quality of the research content, instructional efficiency, or its usage in the industry. The subsequent research must combine bibliometric mapping with qualitative systematic reviews, curriculum analysis, and practitioner views to further enhance educational translation of their results.

Conclusion

The structured analysis of this bibliometric study gives a detailed investigation of this research topic that will soon be known as sustainable textiles. It plots the intellectual, thematic, and collaborative boundaries of the research frontier, and it shows the change of academic leadership to new economies, India, and China. The results support five prevailing fields of knowledge, including material innovation, waste management, policy and governance, digital and Industry 4.0 integration, and cultural literacy, which are important areas requiring curricula innovation. All these tendencies, the growing number of publications, the fact that co-citation networks are interdisciplinary, and the appearance of new research topics are aspects that can lead to a paradigmatic change in the development of the concept of sustainability in teaching textile studies. To stay on par with this tendency, universities and colleges should promptly incorporate the elements of interdisciplinary curricula, data literacy, environmentalism, and systems thinking into the coursework. The future of sustainable textiles should be seen in the ability not only of technological breakthroughs and scientific work to produce results, but also the capacity of teaching systems to create the new generation of principled, imaginative, and insightful textile professionals who understand how to deal with complicated problems at the border of design, environment, and society. The future research is intended to triangulate bibliometric results with a qualitative systematic literature review, curriculum audit, and interviews with textile teachers. This would provide more profound insights into how bibliometric evidence can be applied in teaching and learning activities. It is also advisable to conduct longitudinal monitoring of clusters to track the development of thematic structures over the next decade. Lastly, a shift towards policy analysis is also advised, in order that bibliometric knowledge can be used not only to guide curriculum change, but also to inform textile education accreditation criteria and national policy frameworks.

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Conflict of interest

The authors confirm that there is no conflict of interest involved with any parties in this manuscript.

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