Green threads: a bibliometric review of sustainable manufacturing practices in the fashion industry

AALIYA ASHRAF
ULFAT ANDRABI
SYED MOHD KHALID
RAMONA BIRAU

VIRGIL POPESCU
COSTEL MARIAN IONAȘCU
STEFAN MARGARITESCU
ROXANA-MIHAELA NIOATA (CHIREAC)

ABSTRACT – REZUMAT

Green threads: a bibliometric review of sustainable manufacturing practices in the fashion industry

The significance of sustainable manufacturing has increased, especially in the fast-fashion sector, amid the growing urgency of resource depletion, environmental degradation, and unsustainable industrial practices. To map the thematic and intellectual landscape of research in sustainable fashion and manufacturing, this study performs a thorough bibliometric analysis. This study uses quantitative and qualitative bibliometric techniques using Biblioshiny (R Studio) to identify important trends, powerful authors, high-impact publications, prestigious journals, and emerging research themes based on 194 research documents that were pulled from the Scopus database. The results show that scholarly interest increased significantly after 2015, with significant increases in publications from 2020 to 2023. Two prominent sources are Sustainability (Switzerland) and the Journal of Cleaner Production. Key motor themes like recycling, sustainable development, and the circular economy are highlighted by thematic mapping, and co-authorship networks show prominent collaborative clusters headed by writers like Shamsuzzaman M. and Islam M.T. There are still gaps in regional diversity, interdisciplinary integration, and real-world implementation studies, despite an expanding body of research. For academics, professionals, and legislators hoping to promote sustainable change in the global fashion manufacturing industry, this paper offers strategic insights.

Keywords: *circular economy, green practices, Scopus, sustainability, textile industry, co-authorship network, thematic mapping*

Fire ecologice: o analiză bibliometrică a practicilor de producție sustenabilă în industria modei

Importanța producției durabile a crescut, în special în sectorul modei rapide, din cauza urgenței crescânde legate de epuizarea resurselor, degradarea mediului și practicile industriale nesustenabile. Pentru a cartografia peisajul tematic și intelectual al cercetării în domeniul modei și producției durabile, acest studiu realizează o analiză bibliometrică aprofundată. Acest studiu utilizează tehnici bibliometrice cantitative și calitative folosind Biblioshiny (R Studio) pentru a identifica tendințe importante, autori influenți, publicații cu impact ridicat, reviste prestigioase și teme de cercetare emergente pe baza a 194 de documente de cercetare extrase din baza de date Scopus. Rezultatele arată că interesul academic a crescut semnificativ după 2015, cu creșteri importante ale publicațiilor între 2020 și 2023. Două surse proeminente sunt Sustainability (Elveția) și Journal of Cleaner Production. Teme cheie precum reciclarea, dezvoltarea durabilă și economia circulară sunt evidențiate prin cartografierea tematică, iar rețelele de coautorat arată clustere colaborative proeminente conduse de scriitori precum Shamsuzzaman M. și Islam M.T. Există încă lacune în diversitatea regională, integrarea interdisciplinară și studiile de implementare în lumea reală, în ciuda unei activități de cercetare în expansiune. Pentru academicieni, profesioniști și legiuitori care speră să promoveze schimbări durabile în industria globală a modei, acest articol oferă perspective strategice.

Cuvinte-cheie: *economie circular, practici ecologice, Scopus, sustenabilitate, industria textilă, rețea de coautorat, cartografiere tematică*

INTRODUCTION

Population growth, resource depletion, and environmental degradation are major global issues endangering human survival and advancement. When resources are used to produce goods, toxic environmental pollutants are released. Numerous programs are in place to encourage green practices in the industrial sector in response to growing concerns about resource scarcity and environmental degradation [1, 2]. The objective is to create and advance environmentally friendly production methods.

Manufacturing will continue to play a significant role in wealth creation, job creation, and global economic growth for years to come. As a result, incorporating green practices into manufacturing has been a hot topic lately [3].

In the past ten years, there has been an increase in the number of green initiatives. It is possible for environmental management systems, green supply chain practices, environmental responsibility, and new circular economy practices to make a contribution to the implementation of green industrial policy [4].

"Green manufacturing" (GM) is an emerging method of production that embraces environmentally friendly practices in order to improve efficiency [5]. This technique is referred to as "green manufacturing for the first time". GM is a method or system that maximises sustainability and minimises environmental impact by reusing materials and developing new products that are beneficial to the environment. This is accomplished through the production of environmentally friendly products [6].

According to Deif, General Motors is a paradigmatic example of a new manufacturing paradigm that includes a wide variety of environmentally friendly strategies, drivers, and procedures to maximise resource efficiency [7]. Green product design and green technology must be expressly integrated across the entire manufacturing process for GM to be considered environmentally responsible [8–13]. A great number of businesses have either already adopted genetically modified organisms or are making preparations to do so.

The general public is in agreement that we need to take action in order to protect the natural resources of our world; hence, businesses have the opportunity to improve their image by transitioning to production methods that are more environmentally friendly. In addition, this approach has the potential to save costs for the organisation over the course of time by facilitating the implementation of more efficient systems and the cultivation of a corporate culture that is dedicated to the development of innovative procedures. There is a possibility that the amount of waste that an organisation produces will reduce as a consequence of these more efficient practices [14].

Not only does the term "fast fashion" refer to the concept of speed, but it also refers to a set of practices that are implemented in the fashion market with the intention of achieving continuous growth based on the power and prosperity that the brand represents, as stated by Fletcher. In this sense, the reflection of the change was taken by the large-scale clothing production factories. There was a 6.2% growth in production in the global fashion sector (clothing) in the year 2020 [4]. In 2017, the largest fast fashion company, H&M, achieved 1.4% of the overall market. According to Pang and Zhang [3], the economic performance of the fast fashion business model is significant because of the low pricing and rapid product rotations that encourage excessive consumption, particularly among children and teenagers of the younger generation [15].

Therefore, businesses that had previously built a debut collection for each semester are now beginning to generate numerous entries during the same period of time. In addition, they are increasing the number of products that are created for each collection, which ultimately leads to an increase in the number of sales (markdown) [16]. There are various sustainability concerns, some of which are related to the low reuse and recycling rates during their life cycle, particularly in the post-use phase [17]. Global fashion delivers great economic benefits, but at the same time, there are many problems associated with sustainability. According to the European Materials Federation (2017), the recycling rate in the fashion business is approximately 1%, which is significantly lower than the recycling rate in the plastics sector, which is 14% [18].

Salcedo makes a comment in the social domain on the hazardous and risky working circumstances that are provided by the global textile industry [19]. These conditions are established for the most part in Third World countries such as India and China, where labour is more affordable and does not necessarily have a higher level of qualification. In addition, we bring attention to the fact that children and adolescents are frequently exposed to environments that are not conducive to their health, that employees receive a meager compensation (generally between one and two percent of the total sale price of a piece), and that they are also exposed to a variety of chemicals, insecticides, and other substances that are detrimental to human health and ecosystems.

Several understudied topics are revealed by a bibliometric analysis of the body of research on circular economy practices, sustainability in the fashion industry, and green manufacturing. First off, although the body of research on green manufacturing is expanding, there is still little interdisciplinary integration in the literature, especially when it comes to supply chain management, environmental science, and social sustainability studies. Research clusters typically concentrate primarily on technical or environmental issues, with fewer studies examining socioeconomic factors like consumer behaviour or labour welfare. There is also a clear geographic divide, with most research concentrated in developed economies and little research on developing nations, where fast fashion manufacturing is most common.

Furthermore, as evidenced by low citation counts and little keyword co-occurrence, emerging themes like post-consumer textile waste management and green fast fashion practices are still in their infancy. In order to capture the dynamic evolution of sustainable practices across industries, more real-world case studies, regulatory impact assessments, and longitudinal research are needed. Finally, policy-driven and empirical studies continue to be underrepresented. As a result, the following research questions have been framed:

RQ1: How has the volume of publications on green manufacturing and sustainability in the fashion industry evolved?

RQ2: Who are the most influential authors contributing to research on green manufacturing and sustainability in fast fashion?

RQ3: In which journals is research on green manufacturing and sustainable fashion most frequently published?

RQ4: What are the most frequent words used in green manufacturing research?

RQ5: Which documents have received the highest global citations in sustainability research, and what makes them influential?

RQ6: **What are the key thematic clusters and interconnections in sustainability research, particularly in relation to manufacturing and the fashion industry?**

RQ7: **What are the most influential and emerging research themes in sustainability, based on their relevance and development over time?**

RQ8: **Which authors have collaborated on research related to sustainable manufacturing in the fashion industry?**

To respond to the aforementioned queries, we employed bibliometric network analysis. The bibliometric analysis offers an easily extended perspective from micro to macro levels, in contrast to traditional narrative reviews of the literature based on the researchers' knowledge [20]. One of the best methods for conducting quantitative analyses of scientific findings is bibliometric analysis [21]. The best way to ascertain the conceptual framework of a field of study is through a bibliographic analysis [2, 22].

LITERATURE REVIEW

Human concerns about the environment served as the impetus for the early 1990s introduction of the GM concept [23]. Initially, GM's focus was entirely on processes in an effort to reduce manufacturing waste. After that, the focus switches to the final product, with steps being taken to preserve water, energy, and other natural resources. In a very specific sense, GM is typically understood to refer to the manufacturing of environmentally friendly goods, such as those used in clean technology equipment and renewable energy systems [24]. But in a much larger sense, GM is typically understood to be about putting green strategies into practice, such as waste and resource reduction strategies [3]. The idea is universal in its application, even though it is difficult in a broad sense. In fact, products made with eco-friendly production techniques are considered green [10]. The current body of research typically concentrates on the idea of greening manufacturing processes as a whole. From an economic perspective, "GM" aims to lessen or eradicate the adverse effects of "externalities" on the environment. Businesses view GM practices as advantageous [25].

In keeping with their GM experiments, Herva et al. developed a method to evaluate the environmental impact of a cotton jacket manufacturing facility [26]. A GM system model was presented by Deif [7]. Plans for a more environmentally friendly and efficient manufacturing process are depicted in the model. Businesses' GM practices may be validated based on their strategic goals, behaviour toward stakeholder demands, and stakeholder interests, according to the methodology created by Bigliardi and Bottani [27]. Rehman and Shrivastava conducted a thorough analysis of the GM literature review research [23]. They came to the conclusion that there were different areas of GM research. GM integrates a wide range of procedures into all business operations that have an

effect on the environment. The GM framework for sustainable development in the Indian steel industry was validated by Shrivastava et al. [10]. The study detailed the organisation's GM implementation strategy and how it affected overall performance. Motivators for industrial GM implementation were identified and ranked by Mittal and Sangwan [28]. It was concluded that strong GM regulations and government incentives might aid industries in implementing GM. Arulrajah et al. offered a perspective that exhorts scholars to assess a company's human element in order to ascertain whether or not it adopts green practices [29].

There have been multiple attempts to implement it because of the success factors as well as technical and managerial issues. GM has surfaced in recent years and now covers every phase of the product life cycle, from design to end-use [30]. It refers to the particulars of environmentally friendly manufacturing practices, including pollution control, recycling, conservation, waste management, environmental protection, and regulatory enforcement [10]. In practically every manufacturing activity, green practices are crucial [24–40].

One of the most resource-intensive and environmentally damaging industries, the fashion sector uses a lot of energy, water, and chemicals. It also contributes significantly to greenhouse gas emissions and textile waste [41]. Researchers and policymakers have placed a greater emphasis on sustainable manufacturing practices in recent years as a way to lessen adverse social and environmental effects [33]. The application of circular economy concepts in fashion, which emphasise long-term, reusable, and recyclable design, is being highlighted in an expanding corpus of literature [37]. Waste reduction measures include product take-back programmes, textile-to-textile recycling, and new business models like clothing rental and resale [34].

However, fibre blends, expense, and inadequate infrastructure continue to be obstacles to the scaling of recycling technologies [35].

Sustainable fibres are becoming more popular as a substitute for conventional fibres. In an effort to lessen reliance on virgin polyester and cotton, studies show a growing use of recycled fibres, regenerated cellulosics, and bio-based textiles [40]. Although these materials have the potential to reduce life-cycle impacts, challenges with scalability and performance parity with conventional fibres still exist [42]. Due to the extensive use of chemicals and water, wet processing, especially dyeing and finishing, is a major environmental hotspot. Waterless dyeing techniques that can drastically lower effluent discharge include foam dyeing, enzymatic treatments, and supercritical CO_2 dyeing [36].

Despite their potential, supply-chain fragmentation, fibre compatibility, and cost prevent widespread adoption [40]. The most widely used technique for assessing environmental effects along the clothing value chain is still life cycle assessment, or LCA. Its

function in locating hotspots is highlighted in recent reviews, especially during the stages of raw material production, dyeing, and consumer use [35]. However, accurate evaluations are hampered by inconsistent methodological approaches and a lack of supplier data [34]. For more comprehensive evaluations, the authors suggest incorporating social life cycle assessments (S-LCA) and harmonising LCA standards [41]. A growing priority is the electrification of heat-intensive processes and the adoption of renewable energy sources to decarbonise manufacturing [42]. Cleaner energy systems, like electric heat pumps, are being promoted to supplier factories that frequently use fossil fuel boilers (Vogue Business, 2025). It is believed that financing methods and brand-supplier partnerships are crucial to removing financial obstacles.

Increasingly, efforts are being made to improve efficiency and transparency through digital technologies such as AI-driven supply-chain optimisation, digital product passports, and blockchain-based traceability systems [33]. By decreasing overproduction, enhancing waste management, and facilitating recycling through material traceability, these tools promote sustainable manufacturing. Nevertheless, interoperability issues and implementation costs continue to exist [41]. Beyond environmental issues, fair wages, worker safety, and labour rights must all be considered in sustainable fashion manufacturing. The integration of environmental and social governance (ESG) measures into manufacturing practices is emphasised by scholars [39]. Without more extensive systemic changes like guaranteeing livable wages and increasing supplier capacity, implementing audits alone is insufficient [38].

According to recent studies (2023–2025), scalable applications of sustainable manufacturing practices are emerging in the fashion industry, moving beyond theoretical discussions. Recycling, materials, and cleaner processing innovations are progressing, but widespread adoption is still hampered by systemic issues with costs, policy, data accessibility, and social equity. Harmonised life cycle assessment (LCA) frameworks, supplier decarbonisation investments, extensive circularity infrastructure, and integrated environmental-social approaches must be the main focuses of future research and practices.

METHODOLOGY

Finding databases that support the study is the first stage in the bibliometric analysis process [12]. Information from the Scopus database as of July 12, 2025, served as the basis for this article.

According to Chadegani et al., the Scopus database is the most searchable citation resource and the most comprehensive source for citations and abstracts of literature searches [31]. According to Zhao and Strotmann, Scopus has 60% more coverage than Web of Science. "Manufacturing" and "sustainable" are the two terms that make up the concept of "sustainable manufacturing". In order to guarantee that both terms are included in the results, we conducted separate searches for each of the terms [32]. In the first, all of the potentially relevant keywords linked with sustainable were included, and in the second, all of the sustainable manufacturing practices that were associated with keywords were included. In the end, the search term that we used was (Sustainability) and (sustainable manufacturing in the fashion sector). After conducting this search, a total of 332 documents were found. A total of 204 documents were produced after the first filters were applied to only include papers from the following subject areas: Business, Management and Accounting, Environmental Science, Social Sciences, and Arts and Humanities. Choosing only research articles, review papers, book chapters, and conference papers allowed for even more refinement.

This study's bibliometric analysis is a result of the final screening. A new and continuously evolving field of research serves as the foundation for our analysis; hence, we have concentrated on all of the references contained within the database, which includes conferences and papers from journals that have been subjected to peer review. According to Aria & Cuccurullo, we started the analysis by obtaining important bibliometric, qualitative and quantitative data. This included things like articles authored, authors, citations, country of origin, or keywords [5]. We did this by using a statistical tool that was available on R-Studio. In the realm of bibliometric analysis, Bibliometix is software that is based on R. R is an ecosystem program, which implies that it operates in
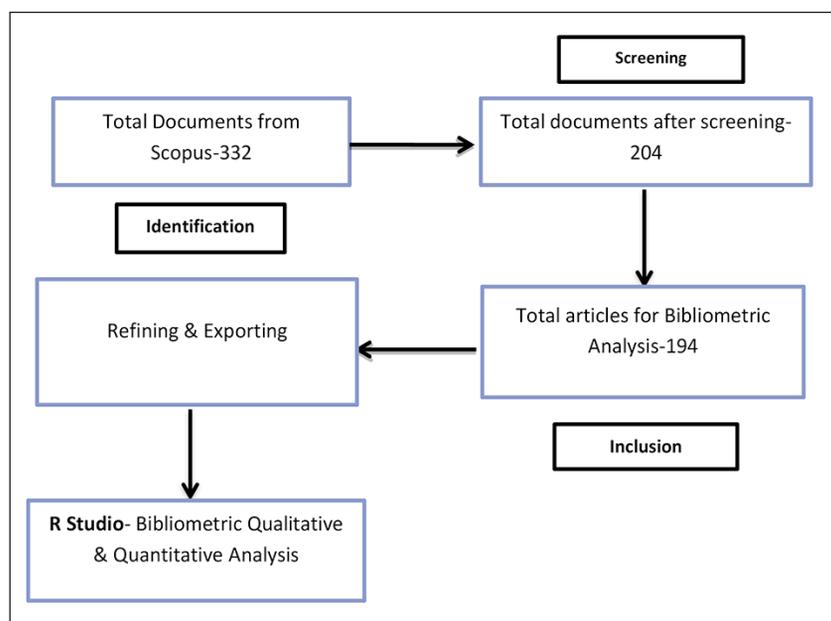

Fig. 1. Search and analysis flow diagram

a cohesive environment with the assistance of a group of open-source components. These components include open-source libraries, algorithms, and graphics applications.

ANALYSIS AND FINDINGS

To answer the research questions of the study, data were taken from the Scopus database and examined using Biblioshiny, the graphical user interface of the Bibliometrix package in R. Scopus was selected as a reliable source for bibliometric analysis due to its extensive coverage, which includes indexed journals, conference proceedings, and book series.

Annual scientific production

As a reflection of the early stages of scholarly interest in this field, the annual scientific production on sustainability in the fashion industry shows an initially modest research output between 2003 and 2014. From 2015 onward, there was a steady rise, indicating growing academic involvement.

Notably, publications increased significantly between 2020 and 2023, reaching a peak of over 40 articles in 2023. This highlights the increased research momentum that may have been fueled by current world events and a growing interest in interdisciplinary topics. Despite a drop in 2024 and 2025, production levels are still significantly higher than in previous years, indicating that the field of study has received ongoing scholarly attention (figures 2 and 3).

Most relevant sources

The most pertinent sources supporting sustainability in fashion research are shown in figure 2. With 17 papers, Sustainability (Switzerland) is the most popular publication among the journals. The Journal of Cleaner Production comes in second with 14 papers (figure 3). This suggests that journals with an emphasis on sustainability and the environment are essential for sharing research in this field. A varied but less extensive range of publication venues was highlighted by the three to four articles each from the remaining sources, which included Food Quality and Preference, Environmental Engineering and Management Journal, and others. The concentration of publications in a small number of core journals indicates favoured platforms for academics and
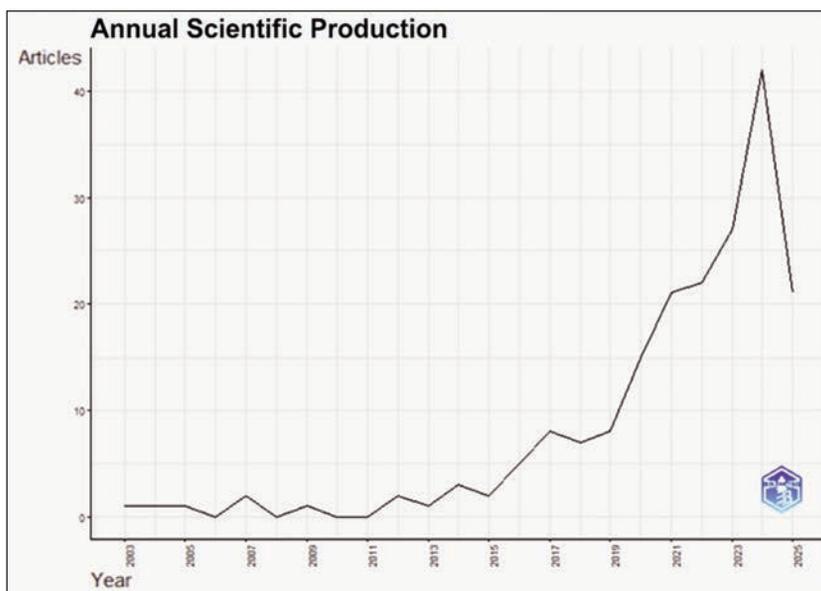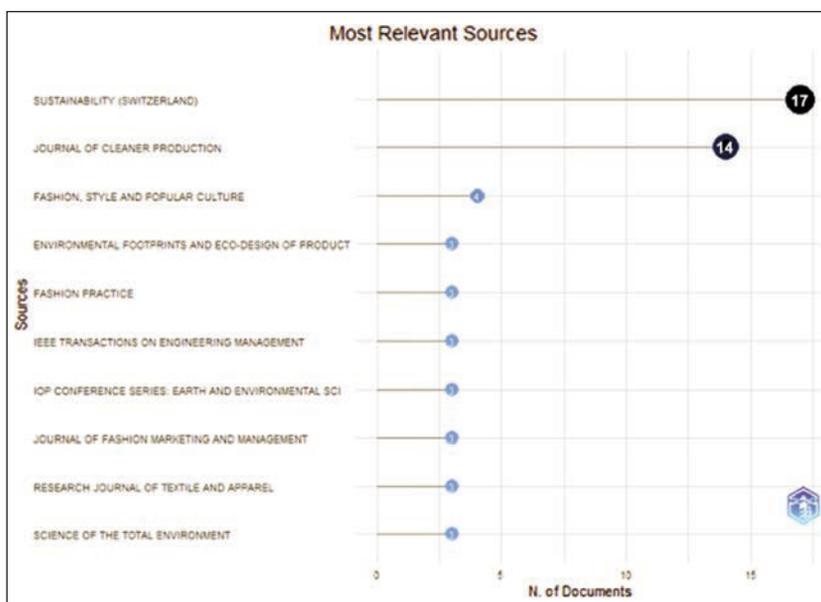

Fig. 2. Year-wise contribution

Fig. 3. Top contributing journals

offers insightful information for upcoming researchers looking for significant publication opportunities.

Bradford's Law is used in figure 4 to show how core sources are distributed, highlighting the journals that make the biggest contributions to the body of knowledge on sustainable manufacturing in the fashion sector. According to the analysis, the Journal of Cleaner Production and Sustainability (Switzerland) are the main core source, publishing the most articles. Although they have fewer contributions, other journals such as Fashion, Style and Popular Culture, Environmental Footprints, and Fashion Practice are also included in the core zone. A significant amount of pertinent research is confined to a small number of journals, as evidenced by the steep drop in article numbers outside of the core sources. This focus identifies key publication platforms for academics and demonstrates the field's interdisciplinary character,
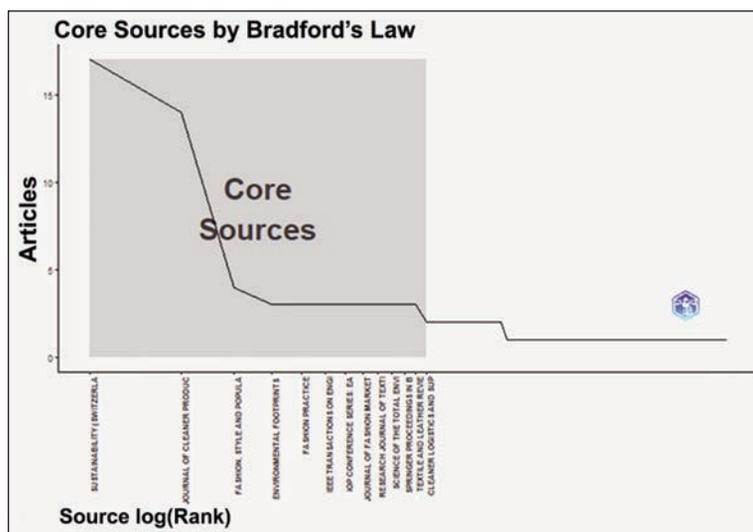
Fig. 4. Core sources by Bradford's Law

which includes sustainability, environmental science, fashion studies, and management research.

The dataset's most productive authors are highlighted in table 1. Four authors, Islam Mazed, Nayak Rajkishore, Niinimäki Kirsi and Shamsuzzaman MD, each contributed three publications, while one scholar leads the cohort with four publications. This implies that a small number of influential people are driving the field's advancement through a concentration of research activity. Ten more academics, including AkterMahmuida and Abbate Stefano, each wrote two articles, suggesting a growing network of up-and-coming authors (table 2).

Numerous highly influential papers in environmental management and sustainable fashion were found by the bibliometric review. As a pioneering study on the environmental effects of fast fashion, Niinimäki et al. (2020) is followed by Shirvanimoghaddam et al. (2020), Bick et al. (2018), Shen (2014), Jung (2014), and Fu (2018), all of whom make substantial contributions to topics like consumer behavior, sustainable supply chains, and the effects of fast fashion. A shift from theoretical reviews to applied and policy-oriented research is evident in recent publications, such as Khairul Akter et al. (2022) and Abbate (2024), which demonstrate growing interest in clean environmental

systems and sustainable development (table 3).

According to the bibliometric keyword analysis, "sustainability" is the most prevalent theme and is closely followed by "sustainable development". The textile and fashion sectors are the main subjects of research, with manufacturing and circular economy strategies receiving a lot of attention. Environmental impact and recycling are frequently discussed topics, suggesting a focus on eco-efficiency and resource management. All things considered, the keywords demonstrate a robust, system-level engagement with sustainability issues and solutions in the textile and fashion industries. By highlighting important thematic clusters and connections between commonly used keywords, the co-occurrence network visualisation demonstrates the intellectual framework of sustainability research. Terms like "sustainability", "sustainable development", and

Table 2

MOST CITED PAPERS	
Paper	**Total Citations**
Niinimäki K., 2020, Nat. Rev. EARTH Environ.	956
Shirvanimoghaddam K., 2020, Sci. Total. Environ.	400
Bick R., 2018, Environ. Heal. Glob. Access Sci. Source	272
Shen B., 2014, Sustainability	230
Jung S., 2014, Int. J. Consum. Stud.	195
Fu B., 2018, Sustainability	173
Khairul Akter M.M., 2022, Clean. Environ. Syst.	145
Cervellon M.C., 2012, J. Fash. Mark. Manag.	129
Islam M.M., 2021, J. Fash. Mark. Manag.	123
Abbate S., 2024, Environ. Dev. Sustain.	110

Table 1

MOST PRODUCTIVE AUTHORS	
Author	**Articles**
Islam Mazed	3
Nayak Rajkishore	3
Niinimäki Kirsi	3
Shamsuzzaman MD	3
Abbate Stefano	2
Akter Mahmuda	2
Atik Md Atiqur Rahman	2
Burak Cakmak	2
Casciani Daria	2

Table 3

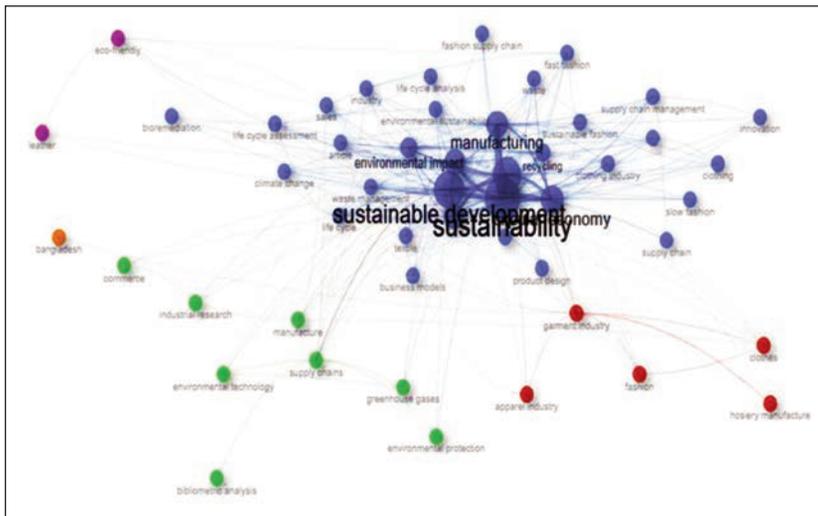| MOST RELEVANT WORDS	
Words	**Occurrences**
sustainability	67
sustainable development	49
textile industry	40
fashion industry	30
manufacturing	30
circular economy	29
textiles	22
environmental impact	19
recycling	16
sustainable fashion	16

Fig. 5. Co-word networks

"manufacturing" predominate at the centre of the map, demonstrating their importance and frequent co-occurrence in academic literature. The focus on industrial and environmental sustainability is reflected in the various clusters that surround these central themes, such as recycling, life cycle assessment, and environmental impact. The fashion and garment industry is the focus of a noteworthy red cluster, with keywords like "fashion", "apparel industry", and "clothes", indicating rising scholarly interest in environmentally friendly textile production methods. A research focus on technological and methodological advancements is suggested by the green cluster, which identifies themes associated with environmen-

tal technology, commerce, and bibliometric analysis. The inclusion of "Bangladesh" as a node highlights the geographic concentration of sustainability concerns in textile-producing regions, while other clusters delve into material-specific subjects like bioremediation and eco-friendly alternatives. With strong connections across the environmental, industrial, and geographic aspects of sustainability, the network map shows a well-developed but dynamic research landscape overall.

The structure and development of sustainability research themes, especially in the manufacturing and fashion industries, are depicted in the thematic map. Important motor themes like recycling, the fashion industry, the circular economy, sustainable development, and the textile sector are all well-developed and extremely pertinent, demonstrating their significant impact in the field. Although they are less developed, fundamental themes like supply chain management, manufacturing, and sustainability are crucial, indicating that they are areas that could use more in-depth research. Niche themes that cater to particular subfields, such as luxury consumption and manufacturing facilities, are well-developed but have little wider relevance. Digital fashion, customisation, and artificial intelligence, on the other hand, are underdeveloped and either gaining traction
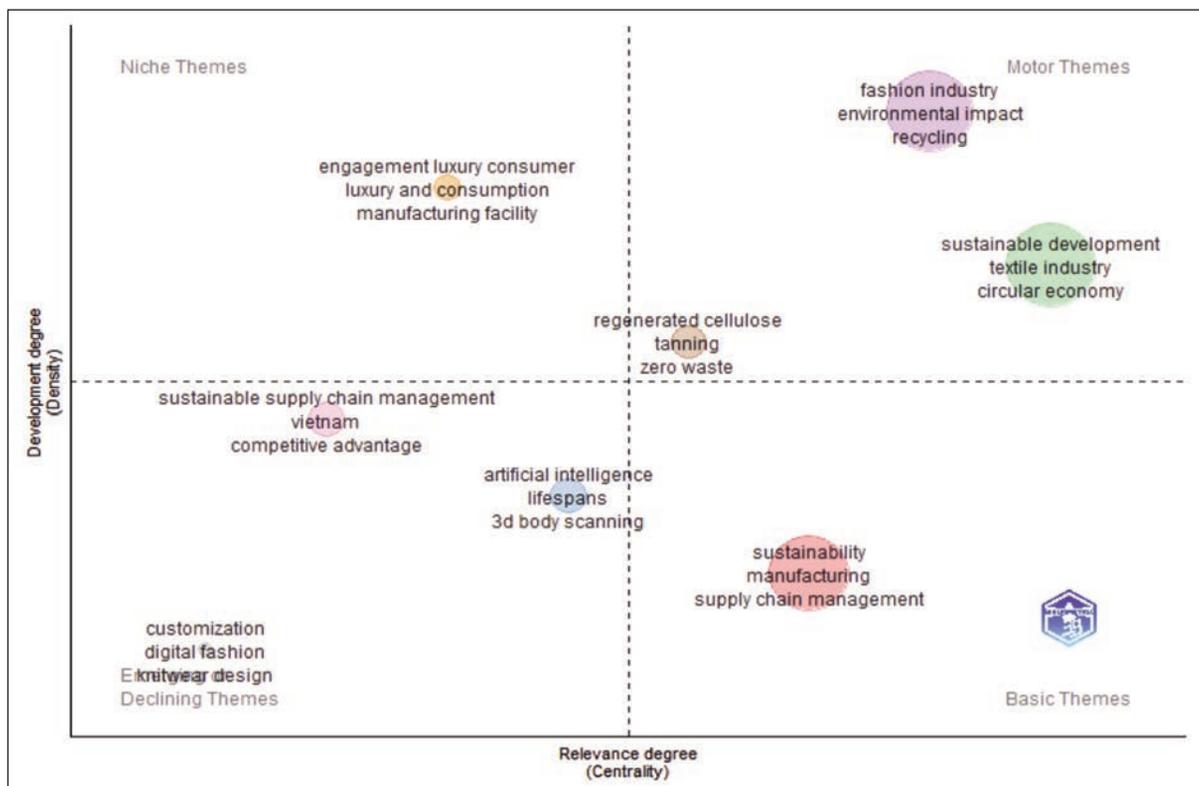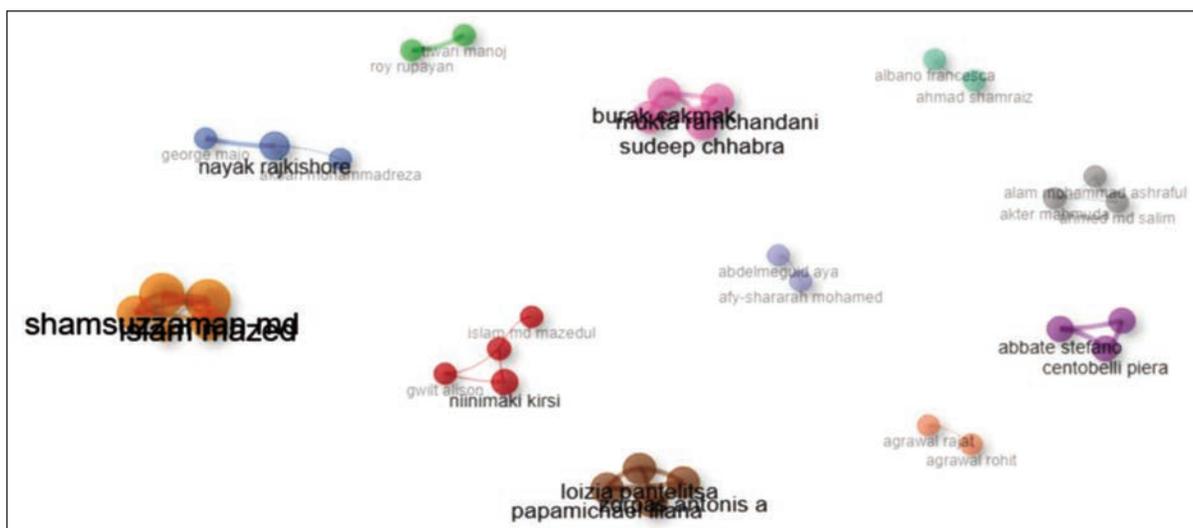

Fig. 6. Thematic map

Fig. 7. Co-authorship network map

or losing relevance, as evidenced by their appearance in the emerging or declining themes quadrant. All things considered, the map offers a strategic summary of the main, emerging, and ancillary areas of sustainability research.

The co-authorship network map highlights different author clusters and shows the collaborative structure among researchers in the field. The most well-known group revolves around Zayed N.M., Islam M.T., and Shamsuzzaman M., suggesting a very active and significant research team.

Collaborations between Burak Erkayman and Sudeep Chhabra, as well as between Loizia P., Papamichael K., and Papadopoulos A., are other noteworthy clusters. These clusters indicate that specialised research teams are making major contributions to their fields. Smaller dyads indicate fewer partnerships with little cross-cluster connectivity. All things considered, the map shows a disjointed but fruitful research environment, with several important writers spearheading cooperative initiatives in their specialised fields.

DISCUSSION

The bibliometric analysis done for this study gives a full picture of how research in sustainable manufacturing in the fashion industry is changing over time. The big rise in publications after 2015, especially between 2020 and 2023, goes along with more people around the world learning about climate change, environmental damage, and how fast fashion makes these problems worse. This rise in academic work shows that people from different fields, like environmental science, business management, and social sciences, are becoming more interested in the same things.

Acloser look at the most productive authors and sources shows how concentrated the field's scholarly contributions are. Journals like Sustainability (Switzerland) and the Journal of Cleaner Production not only have the most articles, but they are also the most relevant.

This shows that people prefer platforms that focus on environmental and sustainability issues. Important writers like Niinimäki K., Shamsuzzaman M., and Nayak R. have become well-known and have written articles that have had a big impact on consumer behaviour, the environmental impact of fast fashion, and the design of sustainable products.

Thematic mapping shows that there are different groups of research activity. Motor themes like recycling, sustainable development, the circular economy, and the fashion industry are well-developed and important to the field. Basic ideas like supply chain management and manufacturing are still important but not fully developed, which means there is room for more research. Digital fashion, customisation, and artificial intelligence are some new ideas that could lead to more sustainable innovation in the future, but they aren't yet widely studied in academia. Moreover, Siminică et al. [43] have highlighted the influence of artificial intelligence in the field of digital transformation and customer service personalization. Ullal et al. also investigated the linkage between green energy and AI, considering the complex implications [44]. Co-word network analysis shows that the research structure is strong but changing. Core keywords like "sustainability", "textile industry", and "environmental impact" are strongly linked to each other. On the other hand, geographic indicators like "Bangladesh" show how important textile manufacturing issues are on a global and regional scale.

Even though the field is growing, the analysis shows that there are still some big gaps. There isn't much collaboration between fields, especially between environmental science and social issues like worker welfare or consumer awareness. Research is still mostly done in developed countries, with few studies coming from developing countries, where most textile manufacturing takes place. There aren't enough empirical and policy-focused studies either, which shows that we need more studies that look at real-world situations over time. The co-authorship network analysis shows that there are scholarly communities

that are broken up but still productive. There are strong groups of authors who work together, especially South Asian and European authors, but there isn't much cross-cluster connectivity.

Encouraging more collaboration between different fields and regions could lead to more new ideas and a bigger impact from research on sustainable manufacturing.

CONCLUSION AND DIRECTIONS FOR FUTURE RESEARCH

This bibliometric study shows that there is a lot of new research being done on sustainable manufacturing in the fashion industry. This is because people are becoming more concerned about the environment and the need for responsible production methods. The study points out important contributors, influential journals, and major research topics like the circular economy, recycling, and sustainable development. It also points out new fields like digital fashion and artificial intelligence that are still growing. The research landscape is still broken up, with few studies done in developing countries and few studies done in developed countries. This is strange because most of the fast fashion manufacturing happens in developing countries.

Future research should work to close these gaps by encouraging studies that bring together environmental science, social sustainability, and supply chain management. We need more real-world case studies and long-term analyses to understand how sustainable practices affect people in the real world. Also, including areas that aren't well represented, especially in Asia and Africa, will give us a better idea of how global sustainability efforts are working. Lastly, studies that are based on policy and research that is done together by schools, businesses, and governments will be very important for turning ideas about sustainability into real plans of action in the fashion manufacturing industry.

REFERENCES

[1] Yacob, P., Wong, L.S., Khor, S.C., *An empirical investigation of green initiatives and environmental sustainability for manufacturing SMEs*, In: J Manuf Technol Manag., 2019, 30, 1, 2–25

[2] Castriotta, M., Loi, M., Marku, E., Naitana, L., *What's in a name? Exploring the conceptual structure of emerging organisations*, In: Scientometrics, 2019, 118, 2, 407–437

[3] Pang, R., Zhang, X., *Achieving environmental sustainability in manufacture: A 28-year bibliometric cartography of green manufacturing research*, In: J Clean Prod., 2019, 233, 84–99

[4] O'Connell, L., *Market growth of the apparel industry worldwide from 2012 to 2020*, Statista, 2019, Available at: https://www.statista.com/statistics/727541/apparel-market-growth-global/ [Accessed on January 10, 2021].

[5] Aria, M., Cuccurullo, C., *bibliometrix: An R-tool for comprehensive science mapping analysis*, In: J Informetr., 2017, 11, 4, 959-975

[6] Dornfeld, D., Yuan, C., Diaz, N., Zhang, T., Vijayaraghavan, A., *Introduction to green manufacturing*, In: Green manufacturing: fundamentals and applications, Boston (MA): Springer, US, 2012, 1–23

[7] Deif, A.M., *A system model for green manufacturing*, In: J Clean Prod., 2011, 19, 14, 1553–1559

[8] Belhadi, A., Kamble, S.S., Zkik, K., Cherrafi, A., Touriki, F.E., *The integrated effect of Big Data Analytics, Lean Six Sigma and Green Manufacturing on the environmental performance of manufacturing companies: The case of North Africa*, In: J Clean Prod., 2020, 252, 119903

[9] Kumar, M., Kumar, A., Sharma, V., *Study of green manufacturing practices through survey-ordinal regression analysis and development of theoretical framework for Ethiopian manufacturing industries*, In: Int J Math Oper Res., 2023, 25, 2, 186–207

[10] Seth, D., Shrivastava, R.L., Shrivastava, S., *An empirical investigation of critical success factors and performance measures for green manufacturing in cement industry*, In: J Manuf Technol Manag., 2016, 27, 8, 1076–1101

[11] Gandhi, N.S., Thanki, S.J., Thakkar, J.J., *Ranking of drivers for integrated lean-green manufacturing for Indian manufacturing SMEs*, In: J Clean Prod., 2018, 171, 675–689

[12] Ahmad, S., Wong, K.Y., *Development of weighted triple-bottom line sustainability indicators for the Malaysian food manufacturing industry using the Delphi method*, In: J Clean Prod., 2019, 229, 1167–1182

[13] Roschangar, F., Colberg, J., Dunn, P.J., Gallou, F., Hayler, J.D., Koenig, S.G., et al., *A deeper shade of green: inspiring sustainable drug manufacturing*, In: Green Chem., 2017, 19, 1, 281–285

[14] Bass, B., *Advantages and disadvantages of green manufacturing businesses*, Small Business, Chron.com. 2021, Available at: https://smallbusiness.chron.com/advantagesdisadvantages-green-manufacturing-businesses-22312.html [Accessed on February 19, 2023]

[15] Zhang, B., Zhang, Y., Zhou, P., *Consumer attitude towards sustainability of fast fashion products in the UK*, In: Sustainability, 2021, 13, 4, 1646

[16] Carvalhal, A., *Fashion with purpose: manifested by the great turnaround,* 2016

[17] Todeschini, B.V., Cortimiglia, M.N., de Medeiros, J.F., *Collaboration practices in the fashion industry: Environmentally sustainable innovations in the value chain*, In: Environ Sci Policy., 2020, 106, 1–11

[18] Fletcher, K., *Slow fashion: An invitation for systems change,* In: FashPract, 2010, 2, 2, 259–265

[19] Salcedo, E., *Ethical fashion for a sustainable future,* 2014

[20] Todeschini, B.V., Cortimiglia, M.N., de Medeiros, J.F., *Collaboration practices in the fashion industry: Environmentally sustainable innovations in the value chain*, In: Environ Sci Policy, 2020, 106, 1–11

[21] Li, L., Lu, J., Fang, H., Yin, Z., Wang, T., Wang, R., et al., *Lattice Boltzmann method for fluid-thermal systems: Status, hotspots, trends and outlook*, In: IEEE Access, 2020, 8, 27649–27675

[22] Shohan, S., Ali, S.M., Kabir, G., Ahmed, S.K., Haque, T., Suhi, S.A., *Building theory of green supply chain management for the chemical industry: An emerging economy context*, In: Manag Environ Qual., 2020, 31, 5, 1285–1305

[23] Rehman, M.A., Shrivastava, R.L., *Green manufacturing (GM): past, present and future (a state of art review),* In: World Rev Sci Technol Sustain Dev., 2013, 10, 1–3, 17–55

[24] Pathak, S.K., Karwasra, K., Sharma, V., Sharma, V., *Analysis of barriers to green manufacturing using hybrid approach: an investigatory case study on Indian automotive industry*, In: Process Integr Optim Sustain., 2021, 5, 3, 545–560

[25] Afum, E., Agyabeng-Mensah, Y., Sun, Z., Frimpong, B., Kusi, L.Y., Acquah, I.S.K., *Exploring the link between green manufacturing, operational competitiveness, firm reputation and sustainable performance dimensions: a mediated approach*, In: J Manuf Technol Manag., 2020, 31, 7, 1417–1438

[26] Herva, M., Franco, A., Ferreiro, S., Alvarez, A., Roca, E., *An approach for the application of the ecological footprint as environmental indicator in the textile sector*, In: J Hazard Mater., 2008, 156, 1–3, 478–487

[27] Bigliardi, B., Bottani, E., *Green manufacturing practices in the fashion supply chain: lessons from Italian case studies*, In: Int J Agile Syst Manag., 2012, 5, 1, 4–28

[28] Mittal, V.K., Sangwan, K.S., *Prioritizing barriers to green manufacturing: environmental, social and economic perspectives*, In: Procedia CIRP, 2014, 17, 559–564

[29] Arulrajah, A.A., Opatha, H.H.D.N.P., Nawaratne, N.N.J., *Green human resource management practices: A review*, In: Sri Lankan J Hum Resour Manag., 2015, 5, 1

[30] Digalwar, A.K., Mundra, N., Tagalpallewar, A.R., Sunnapwar, V.K., *Road map for the implementation of green manufacturing practices in Indian manufacturing industries: An ISM approach,* In: Benchmarking, 2017, 24, 5, 1386–1399

[31] Chadegani, A.A., Salehi, H., Yunus, M.M., Farhadi, H., Fooladi, M., Farhadi, M., et al., *A comparison between two main academic literature collections: Web of Science and Scopus databases*, arXiv preprint, 2013, arXiv:1305.0377

[32] Zhao, D., Strotmann, A., *Analysis and visualization of citation networks,* San Rafael (CA): Morgan & Claypool Publishers, 2015

[33] Abdelmeguid, A., *Towards circular fashion: Management strategies for sustainable manufacturing*, In: Journal of Cleaner Production, 2024

[34] Abagnato, S., *LCA applications to reuse, recycling, and sustainable apparel supply chains,* In: Sustainability Journal, 2024

[35] Ahmed, S., *Life cycle assessment to advance the fashion industry's sustainability: A review*, In: SAGE Open Sustainability, 2025

[36] Catarino, M.L., *Sustainable wet processing technologies for the textile industry*, In: Sustainability, 2025, 17, 5, 2231

[37] Ellen MacArthur Foundation, *Circular economy in the fashion industry. Ellen MacArthur Foundation Report*, 2023

[38] Fashion Revolution, *Clean heat and supplier decarbonisation in global fashion supply chains. Vogue Business & Fashion Revolution Report*, 2025

[39] Geneva Environment Network, *Environmental sustainability in the fashion industry: Global overview. UNEP/GEN Report,* 2025

[40] Schmidt-Przewozna, K., *Green sustainable textile supercritical dyeing process*, In: Journal of Textile Science and Engineering, 2023, 59, 3, 215–229

[41] Schiaroli, V., *Mapping sustainable options in the fashion industry: A systematic review*, In: Sustainable Development, 2025, 33, 4, 145–162

[42] Tawiah, B., *Sustainable fashion transition towards net-zero future*, In: Journal of Fashion Marketing and Management, 2025, 29, 2, 210–229

[43] Siminică, M.I., Cîrciumaru, D., Manta, A.G., Cârstina, S., Badareu, G., Gherțescu, C., *FinTech, artificial intelligence, and European Union banks: A double-edged sword for performance?*, In: Oeconomia Copernicana, 2025, 16, 3, 1099–1176, https://doi.org/10.24136/oc.3798

[44] Ullal, M.S., Anand, A., Popescu, V., Birau, R., *Investigating the nexus between green energy and artificial intelligence (AI)*, In: Annals of the „Constantin Brâncuşi" University of Târgu-Jiu, Economy Series, 2024, 6/2024, II, 84–90, „Academica Brâncuşi" Publisher, ISSN 2344–3685/ISSN-L 1844–7007

Authors:

AALIYA ASHRAF[1], ULFAT ANDRABI[2], SYED MOHD KHALID[3], RAMONA BIRAU[4,5], VIRGIL POPESCU[6],
COSTEL MARIAN IONAȘCU[6], STEFAN MARGARITESCU[4], ROXANA-MIHAELA NIOATA (CHIREAC)[4]

[1]Chandigarh University, Assistant Professor, University School of Business, Chandigarh, Punjab, India
e-mail: aaliya123ashraf@gmail.com

[2]Mittal School of Business, Assistant Professor, Lovely Professional University, Jalandhar, India
e-mail: Ulfatandrabi456@gmail.com

[3]Pyramid College of Business and Technology, Assistant Professor, Department of Management,
Jalandhar, Punjab, India
e-mail: Syedkhalid491@gmail.com

[4]University of Craiova, "Eugeniu Carada" Doctoral School of Economic Sciences, Craiova, Romania
e-mail: stefanitamargaritescu@gmail.com, roxananioata06@gmail.com

[5]"Constantin Brâncuși" University of Târgu Jiu, Faculty of Economic Science, Tg-Jiu, Romania

[6]University of Craiova, Faculty of Economics and Business Administration, Craiova, Romania
e-mail: virgil.popescu@vilaro.ro; icostelm@yahoo.com

Corresponding author:
RAMONA BIRAU
e-mail: ramona.f.birau@gmail.com