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Textile Industry 4.0: A Review of Sustainability in Manufacturing

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Abstract

This research was done to provide a general understanding and overview of sustainability in manufacturing/textile industries. This research includes the evaluation of the impact of production, processing and consumption of textiles on the environment, economy and society. The key components of a sustainability review of the textile industry include: 1. Design of sustainable products and materials - Evaluation of the existing technological processes (such as production and manufacturing practices, eco-friendly producers, building and designing for sustainability, etc.) 2. Promotion and development of responsible raw material taking into account ecological and social criteria. 3. Product life cycle. Overall, sustainability review of the textile industry can help identify and implement measures for bettering the environment, economy, and society and ensure long-term stability in the sector. This process can also help reduce emissions, waste, and other hazards associated with the industry and promote responsible sourcing of raw materials and production processes. The studied findings were discussed critically along with their advantages and disadvantages. Furthermore, further research should also be done in order to understand the best practices product life cycle of textiles and to improve production and consumption patterns.

Keywords: Textile Industry 4.0, Fashion Industry, Sustainability, Manufacturing Practices

Introduction

The history of sustainability in the textile industry dates back to the 1960s, when Rachel Carson's book Silent Spring highlighted the devastating impact of industrial chemicals on the health of ecosystems. This marked the beginning of the environmental movement, and provided a foundation for sustainability initiatives in the textile industry. In the decades that followed, people began to recognize the importance of reducing our fossil fuel consumption and increase in sustainable practices in the textile industry. In 1987, the United Nations Brundtland Commission defined sustainable development, which focuses on the harmonious balance between necessity of recent and future generations [1]. In the early 2000s, the international sustainable development goals (SDGs) framework was implemented in order to create a more equitable, prosperous and sustainable world. Today, many organizations in the textile industry are implementing a number of measures to ensure sustainability in their production processes, from the sourcing of sustainable raw materials to the design of eco-friendly and ethically produced products. Moreover, many of these organizations are also working towards making their entire supply chain more sustainable by promoting ethical labour, health and safety standards, and fair wages for workers [2].

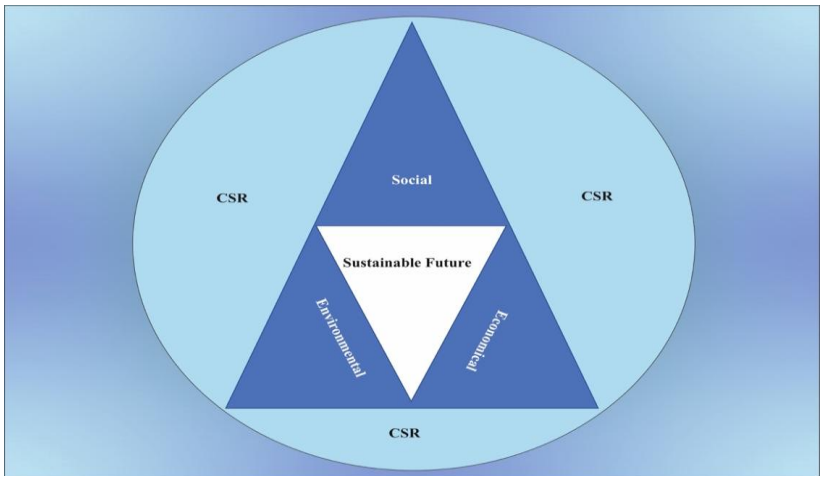

Figure 1. Sustainability Model [41]

The concept of sustainability in the textile industry originates from the idea that the use of resourcesshould be done so in an efficient and responsible manner, so as to not compromise the environment or the livelihoods of those working in or dependent on the industry [3]. Sustainability in the textile industry is an increasingly growing concept, with organizations and stakeholders recognizing the importance of employing sustainable practices in order to ensure long-term viability and success. The concept of sustainability in the textile industry includes principles such as sustainable resource use, efficient energy and water use, responsible management of materials, reducing waste and pollution, promoting fair labour standards, and providing safe and healthy working environments. Sustainability in the textile industry also involves considering effects of its products and services. The concept of sustainability within the textile industry is further supported by an increasing number of eco-friendly and sustainable textile production processes [4]. Sustainable textiles production processes include the use of certified organic wool and cotton, as well as new manufacturing processes and technologies, such as closed-loop systems, that conserve water and energy, produce minimum waste, and include employee safety and welfare. In order to make sure that the textile industry runs in an efficient and responsible manner, regulatory measures are often put in place to ensure the implementation of sustainable practices. This includes environmentally-friendly textile production standards, fair labour practices, and the reduction of the use of hazardous chemicals and materials. With increased efforts towards sustainability by the textile industry, it is hoped that organizations, stakeholders and consumers will benefit from a healthier, more resource-efficient and more economically viable textile industry [5] .

Sustainability is an umbrella term encompassing environmental, economic, and social aspects and a driving force in the pursuit of a more just and equal world. Environmentally, sustainability means striving for balance and protecting natural resources for future generations [6]. This includes reducing our reliance on fossil fuels, managing waste, protecting ecosystems, and reducing emissions and pollution. Economically, sustainability centres on equitable, accessible, sustainable and resilient economic systems. This means creating economic opportunities and systems that support long-term wealth-building, especially in communities that are traditionally underrepresented in the workforce. Socially, sustainability is about people. It means having policies and systems in place that ensure everyone has access to basic necessities and rights, such as healthcare, education, housing, and food. It also means striving for diversity in the workplace, making sure employees' rights are respected and protected, and promoting social initiatives that support a sense of community [7].

Theoretical Conceptualisation of Sustainability

Environmental Sustainability

Environmental sustainability includes reducing material and energy input and waste, utilizing renewable resources, and enhancing natural landscapes where possible [8]. This is an important area to focus on, as the production and manufacturing of textiles requires large amounts of electricity, water and chemicals that can lead to a range of environmental issues.

Examples of textile industry include:

- Investing in sustainable materials such as organic cotton and recycled fabrics.
- Improving water efficiency in all stages of production, including dyeing, spinning and finishing.
- Reducing the usage of hazardous chemicals
- Optimizing energy use, including investing in green technologies such as solar panels.
- Increasing transparency throughout the supply chain to ensure accountability.
- Promoting a circular economy by redesigning products, encouraging reuse and recycling, and investing in other innovative solutions.

With more and more companies in the textile industry embracing environmental sustainability, the sector is slowly transitioning to a future that is much less reliant on natural resources and much more protective of our planet [9].

Environmental sustainability involves creating sustainable management practices to limit or mitigate effects, such as reducing pollution and resource consumption, conserving natural resources, promoting green technologies, and preserving biodiversity. Actions for environmental sustainability would involve encouraging the use of renewable energy, investing in green infrastructure, protecting natural habitats and ecosystems, promoting sustainable food production and reducing waste [10].

Social Sustainability

The textile industry has a significant impact on social sustainability in terms of its production and marketing practices, labour and human rights, health and safety, and environmental management. In terms of social sustainability, the textile industry is increasingly striving to create ethical production practices, providing all employees with fair wages, and promoting healthy and safe working conditions. Significant efforts are also being made to alleviate poverty in local supply chains by increasing transparency and traceability, establishing sustainable working standards, and investing in raw materials from suppliers that comply with social and environmental standards [11]. Additionally, the

industry has made progress in improving its environmental impacts by developing more ecologically sustainable materials and processes.

Social sustainability is concerned with creating and maintaining equitable relationships between people and their environment. Examples of social sustainability include empowering communities to be part of the decision-making process through participatory democracy, promoting financial inclusion and access to resources, and advocating for equitable distribution of wealth and resources [12]. General actions for social sustainability include investing in programs that address poverty and inequality, advocating for justice and equity, and supporting education and job opportunities that embrace diversity [13].

Economic Sustainability

Economic sustainability in the textile industry includes managing production processes and maintaining financial stability by operating in an economic manner that is both socially and ecologically responsible. The industry is transitioning to become more economically sustainable by pursuing more efficiency and waste reduction within the production process, renewable energy for its manufacturing techniques, and looking for more cost-effective raw material alternatives to traditional resources [14]. Additionally, increased transparency and traceability throughout the global supply chain is helping to strengthen economic sustainability as producers are more aware of the social and environmental impact of their manufacturing practices. The industry is also leveraging new technologies to anticipate consumer trends, reduce waste, and increase its overall profitability [15].

Sustainability in Textile Industry

Population growth has had a significant impact on the textiles across the globe. The economies has seen an increase in the production of cotton and other textiles, leading to a larger global market for these materials. In addition, with more people wanting to enjoy the benefits of clothing made from these materials, this has in turn increased the demand for clothing, creating a larger market for the textile industry. Furthermore, as people continue to move to cities with higher populations, the demand for textiles and clothing is likely to continue to rise [16].

The apparel and textile is largest industry, producing over 100 million metric tonnes of products each year. This includes textile fibres and fabrics, which are then used to make clothing and apparel. The industry has grown significantly in recent years. As a result, the apparel and textile industry is coming under increasing pressure to reduce its environmental and social impacts, with the rise of current sustainability trends [17]. This has triggered the development of more sustainable materials and processes, such as the use of recycled materials, renewable energy sources, and new technologies. By improving these sustainability practices, the industry will not only help reduce its environmental impact, but also become more economically viable [18].

Textiles are produced using a variety of materials, chemicals, dyes and treatments, many of which have been found to have a drastic impact on the environment in their production and disposal. The industry is also responsible for releasing a large amount of greenhouse gases, toxic chemicals, and other pollutants into the atmosphere, leading to a range of health and environmental concerns [19]. To mitigate these effects, the industry is increasingly investing in more sustainable production methods, such as using eco-friendly materials and methods to reduce water usage, and reducing chemical waste. This has been beneficial in both reducing the industry's environmental impact, as well as improving its economic sustainability [20].

Additionally, while the textiles may themselves be biodegradable, the large amount of chemical dyes and additives used during production are not, leading to further environmental concerns [21] . To reduce these impacts, the industry must invest in more sustainable materials and processes, Through more sustainable production, the industry can help minimize its environmental harm while also becoming more economically viable[22].

For example, Patagonia has committed to using only renewable energy and decreasing their use of synthetic fabrics [23]. Nike has adopted a 'Zero Carbon Footprint' pledge, setting ambitious goals to reduce their greenhouse gas emissions and use more materials made from recycled and sustainable sources [24]. Additionally, many textile companies have adopted initiatives to reduce their water usage, improve labour conditions in their supply chains, and help protect natural ecosystems and biodiversity [25]. By committing to these goals, these companies can ensure they are both economically viable and socially responsible with their business practices [26].

The production of textiles involves the use of a variety of materials and chemicals, which can have a drastic impact on the environment [27]. These chemicals are used for a variety of processes, such as dyeing and finishing, and can be released into the atmosphere, polluting local ecosystems and posing a health risk to humans. By investing in more sustainable materials and methods of production, the textile industry can help reduce its environmental

impact while becoming more economically viable [28].

Additionally, the production of virgin polyester for use in fabric manufacturing consumes huge amount of oil. These unsustainable production practices contribute to pollution, water shortages, and energy inefficiency, as well as other environmental and economic issues [29]. To reduce these impacts, the industry must invest in more sustainable materials and processes, such as renewable energy sources, eco-friendly fabrics, and by-products from the production process [30]. By making these improvements, the industry can reduce the amount of freshwater and oil used, while also becoming more economically viable.

To reduce these impacts, fast fashion companies must continue to invest in more sustainable practices, such as using materials with low environmental impacts, reducing water usage, improving labour conditions, and increasing transparency and traceability in their supply chains [31]. Additionally, consumers can help reduce this waste by investing in quality garments that will last longer, choosing brands that have committed to sustainability, and donating clothing to those in need. With these improvements, fast fashion companies can help move towards a more sustainable clothing culture [32].

Textile production operations, as with all production operations, have a direct and often significant impact on the environment. Environmental concerns within the textile industry are wide ranging and include the use of hazardous chemicals, water and air pollution, greenhouse gas emissions, energy consumption, and the large-scale impacts of industrial farming for raw material production [33]. To reduce negative environmental impacts, the textile industry is turning to processes and technologies that are considered sustainable and circular. These include methods like closed loop production systems and reusing or recycling of fabrics, dyes, and chemicals, as well as embracing alternative energy sources. Additionally, sustainability-driven innovations such as waterless dyeing, microfiber and nanotechnology filtration, and biobased materials are allowing brands to minimize their environmental footprints [34].

Furthermore, the Sustainable Apparel Coalition (SAC) was established in 2011 with the mission to reduce the environmental and social impacts of apparel and footwear products. The organization developed the HIGG Index, a web-based tool which helps companies score their sustainability performance [35]. This allows companies to measure their impacts and compare the performance of their products and production processes to other industry standards. The textile industry is beginning to realize the importance of social and environmental responsibility and is taking active steps to make its production more sustainable. Sustainable textiles have become an attractive option for many consumers, creating opportunities to help transform the textile industry while satisfying customer expectations. In the long run, sustainable textiles can promote good corporate citizenship, support economic growth, and preserve resources for future generations[36].

The ISO standards in the textile industry encourage organizations to consider sustainability throughout the production process. Organizations must assess their environmental and social impacts and work to reduce their environmental footprint by utilizing efficient production processes, investing in innovative materials, and setting sustainability standards[37]. Additionally, organizations must ensure safety and performance throughout the production process through quality control practices and engaging customers in exploring sustainability solutions [38]. In conclusion, the ISO standards provide a valuable tool that organizations within the textile industry should utilize in order to ensure their product's life cycle meets sustainability goals [39]. Organizations must actively work to reduce their environmental impacts, support ethical practices, and engage customers in order to advance sustainable practices in the textile industry [40]. Based on ISO standards, following are the phases of product life cycle:

1. Material Extraction and Production
2. Material Processing
3. Manufacturing
4. Use, Disposal and Recycling
5. End of Life Disposal

To promote sustainability, companies will need to reduce their use of hazardous materials, implement efficient production processes, and invest in innovative materials and products [41]. Additionally, companies must take an active role in setting sustainability standards, engaging suppliers and customers in exploring sustainability solutions, and utilizing quality control practices to ensure fabric and garment safety and performance [42]. In conclusion, the textile industry still has much work to do to move toward greater environmental sustainability, but there are promising indications that the industry is willing and able to take on the challenge [43]

Conclusion

This research focuses on the industry's use of resources, its production processes, and its impacts on air and water quality. They also examine how the industry utilizes renewable resources and looks at the potential for the use of environmentally friendly

materials and processes. Additionally, much of this research has focused on the potential for the industry to reduce its environmental footprint through the adoption of technological advancements, improved production systems, and the use of more sustainable fabrics and fibers. This research also explores how the industry can contribute to the preservation of resources and social welfare. Such a review of previous work can also potentially reveal major gaps in the existing knowledge base, indicating keywords and topics that require further exploration. By understanding how research has progressed in the past, future research can more easily focus on areas that have yet to be adequately explored and can strengthen the foundation of knowledge in the textile and apparel industry.

Additionally, stakeholders in the industry should collaborate to develop objective, verifiable standards to improve environmental responsibility. Finally, future research should also be conducted to investigate effective ways to incentivize companies to adopt more sustainable practices such as increased resource efficiency and cleaner production. By developing and employing more social and economic indicators to review the performance of companies in the textile and apparel industry, we can help ensure that levels of sustainability are maintained and improved upon.

References

[1]. Basiago AD (1999) Economic, social, and environmental sustainability in development theory and urban planning practice. The Environmentalist 19:145–161

[2]. Rathore, R.S., Sangwan, S., Prakash, S., Adhikari, K., Kharel, R. and Cao, Y., 2020. Hybrid WGWO: whale grey wolf optimization-based novel energy-efficient clustering for EH-WSNs. *EURASIP Journal on Wireless Communications and Networking*, *2020*(1), pp.1-28.

[3]. Kumar, M., Kumar, S., Kashyap, P.K., Aggarwal, G., Rathore, R.S., Kaiwartya, O. and Lloret, J., 2022. Green communication in internet of things: A hybrid bio-inspired intelligent approach. *Sensors*, *22*(10), p.3910.

[4]. Daly HE (ed) (1973) Towards a steady state economy. Freeman, San Francisco

[5]. Diviney E, Lillywhite S (2009) Travelling textiles, a sustainability roadmap of natural fibre garments, Brotherhood of St Laurence, Australia, May 2009

[6]. Population Matters (2021) Sustainability and the Ehrlich equation, glossary in depth, 2021.Available at: https://www.populationmatters.org/wp-content/uploads/ipat.pdf

[7]. Rankin WJ (2014) Chapter 4.1: Sustainability, treatise on process metallurgy, vol 3, pp 1376–1424

[8]. Kumar, S., Rathore, R.S., Mahmud, M., Kaiwartya, O. and Lloret, J., 2022. BEST—Blockchain-Enabled Secure and Trusted Public Emergency Services for Smart Cities Environment. *Sensors*, *22*(15), p.5733.

[9]. Rathore, R.S., Sangwan, S. and Kaiwartya, O., 2021. Towards Trusted Green Computing for Wireless Sensor Networks: Multi Metric Optimization Approach. *Adhoc& Sensor Wireless Networks*, *49*.

[10]. World Commission on Environment and Development (1987) World commission on environment and development-our common future. Oxford University Press, New York

[11]. Bertolotti M (2015) Masers and lasers: an historical approach, 3rd edn. CRC Press, Boca Raton, Florida, pp 89–91

[12]. Rathore, R.S., Sangwan, S., Kaiwartya, O. and Aggarwal, G., 2021. Green communication for next-generation wireless systems: optimization strategies, challenges, solutions, and future aspects. *Wireless Communications and Mobile Computing*, *2021*, pp.1-38.

[13]. Rathore, R.S., Sangwan, S., Adhikari, K. and Kharel, R., 2020. Modified echo state network enabled dynamic duty cycle for optimal opportunistic routing in EH-WSNs. *Electronics*, *9*(1), p.98.

[14]. Srivastava, S.N., Kshatriya, S. and Rathore, R.S., 2017. Search Engine Optimization in E-Commerce Sites. *International Research Journal of Engineering and Technology (IRJET)*, *4*(5), pp.153-155.

[15]. Rattan, V., Sinha, E.M., Bali, V. and Rathore, R.S., 2010. E-Commerce Security using PKI approach. *International Journal on Computer Science and Engineering*, *2*(5), pp.1439-1444.

[16]. Choi JI, Chung YJ, Kang DI, Lee KS, Lee JW (2012) Effect of radiation on disinfection andmechanical properties of Korean traditional paper, Hanji. Radiat Phys Chem 81(8):1051–1054

[17]. Deirdre S, Riach K (2011) Embracing ethical fields: constructing consumption in the margins.Eur J Mark 45(7–8):1051–1067

[18]. Rathore, B., 2022. Supply Chain 4.0: Sustainable Operations in Fashion Industry. *International Journal of New Media Studies (IJNMS)*, *9*(2), pp.8-13.

[19]. Gardetti M, Muthu S (2015) Sustainable apparel? Is the innovation in the business model?— The case of IOU project. Text Clothing Sustain 1(1):1–9

[20]. Hethorn J, Ulasewicz C (2015) Sustainable fashion: what's next? A conversation about

issues,practices and possibilities. Fairchild Books, New York

[21]. Joy A, Sherry J-F, Venkatesh A, Wang J, Chan R (2012) Fast fashion, sustainability, and theethical appeal of luxury brands. Fashion Theor 16(3):273–296

[22]. Rathore, B., 2021. Fashion Transformation 4.0: Beyond Digitalization & Marketing in Fashion Industry. *Eduzone: International Peer Reviewed/Refereed Multidisciplinary Journal*, *10*(2), pp.54-59.

[23]. Rathore, B., Digital Transformation 4.0: A Case Study of LK Bennett from Marketing Perspectives.

[24]. Jung J-Y, Lee J-H, Park C-G (2013) Effect of styrene–butadiene latex on the bond performance of macro synthetic fiber in micro jute/macro synthetic hybrid fiber-reinforced latex-modifiedcement-based composites. J ApplPolym Sci 127(5):3522–3529

[25]. Kadolph S-J (2007) Textiles, 10th edn. Prentice-Hall, Upper Saddle River, New Jersey, USA

[26]. Rathore, B., 2022. Impact of Green Marketing on Sustainable Business Development. Cardiff Metropolitan University. Presentation.

[27]. Dr. Bharati Rathore. (2023). Digital Transformation 4.0: Integration of Artificial Intelligence & Metaverse in Marketing. *Eduzone: International Peer Reviewed/Refereed Multidisciplinary Journal*, *12*(1), 42–48. Retrieved from https://www.eduzonejournal.com/index.php/eiprmj/article/view/248

[28]. Kant R (2012) Textile dyeing industry an environmental hazard. Natural Science 4(1):22–26Khalil E (2015) Sustainable and ecological finishing technology for denim jeans. AASCITCommun 2(5):159–163

[29]. Khan MR, Islam M (2015) Materials and manufacturing environmental sustainability evaluation of apparel product: knitted T-shirt case study. Textiles and Clothing Sustainability 1(1):1–12

[30]. Rathore, R.S., Kaiwartya, O., Qureshi, K.N., Javed, I.T., Nagmeldin, W., Abdelmaboud, A. and Crespi, N., 2022. Towards enabling fault tolerance and reliable green communications in next-generation wireless systems. *Applied Sciences*, *12*(17), p.8870.

[31]. Tomar, R. and Rathore, R.S., 2016. Privacy Preserving in TPA using Secured Encryption Technique for Secure Cloud. *International Journal of Computer Applications*, *138*(8).

[32]. Parsons School of Design (2011) Reap what you sew: Zero waste fashion at Parsons. http://blogs.newschool.edu/news/2011/02/zero-waste-fashion/#.VvtKAbR_dds.

[33]. Patagonia (2015) Patagonia to cease purchasing wool from Ovis 21. http://www.patagonia.com/us/patagonia.go?assetid=9895.

[34]. Dr. Bharati Rathore (2023) "Integration of Artificial Intelligence& It's Practices in Apparel Industry ", *International Journal of New Media Studies (IJNMS)*, 10(1), pp. 25–37. Available at: https://ijnms.com/index.php/ijnms/article/view/40 (Accessed: 27 February 2023).

[35]. Patagonia (N.D.b) Recycled polyester.

a. http://www.patagonia.com/us/patagonia.go?assetid=2791.

[36]. Roy Choudhury AK (2015) Development of eco-labels for sustainable textiles, Roadmap toSustainable Textiles and Clothing, Text Sci Clothing Technol 137–173

[37]. Rydell R (2001) Nylon: The Story of a Fashion Revolution. Business History Review 75(1):210–212

[38]. Rathore, B., 2022. Textile Industry 4.0 Transformation for Sustainable Development: Prediction in Manufacturing & Proposed Hybrid Sustainable Practices. *Eduzone: International Peer Reviewed/Refereed Multidisciplinary Journal*, *11*(1), pp.223-241.

[39]. Rathore, B., Digital Transformation 4.0: A Case Study of LK Bennett from Marketing Perspectives.

[40]. Stern N-Z, Ander W-N (2008) Greentailing and other revolutions in retail: hot ideas that aregrabbing customer's attention and raising profits. Wiley, Hoboken, New Jersey

[41]. Rathore, B., 2022. Supply Chain 4.0: Sustainable Operations in Fashion Industry. *International Journal of New Media Studies (IJNMS)*, *9*(2), pp.8-13.

[42]. Van der Veldena NM, Kuuskb K, Köhlerc AR (2015) Life cycle assessment and eco-design ofsmart textiles: the importance of material selection demonstrated through e-textile productredesign. Materials & Design 84(5):313–324

[43]. Rathore, B., 2021. Fashion Transformation 4.0: Beyond Digitalization & Marketing in Fashion Industry. *Eduzone: International Peer Reviewed/Refereed Multidisciplinary Journal*, *10*(2), pp.54-59.