Sandaruwan, I.P.T., Waidyasekara, K.G.A.S. and Zainudeen, N., 2023. Management of carbon footprint in apparel industry: A systematic literature review. In: Sandanayake, Y.G., Waidyasekara, K.G.A.S., Ramachandra, T. and Ranadewa, K.A.T.O. (eds). *Proceedings of the 11th World Construction Symposium*, 21-22 July 2023, Sri Lanka. [Online]. pp. 740-752. DOI: https://doi.org/10.31705/WCS.2023.60. Available from: https://ciobwcs.com/papers/

MANAGEMENT OF CARBON FOOTPRINT IN APPAREL INDUSTRY: A SYSTEMATIC LITERATURE REVIEW

I.P. Tharindu Sandaruwan[1], K.G.A.S. Waidyasekara[2] and Nisa Zainudeen[3]

ABSTRACT

Climate change is a significant challenge confronting humanity today. Public and private experts in developed and developing countries along with a few non-governmental organisations (NGOs) worldwide are attempting to reconcile monetary expansion with its adverse effects on climate change. The apparel sector is now the second-largest industrial polluter, contributing 10% of the world's carbon emissions. Therefore, the main aim of this study is to investigate potential strategies to minimise carbon footprint (CFP) in the apparel sector. The study selected a systematic literature review based on the PRISMA method methodology and content analysis was used as the analysis technique. The findings spotlight that energy, solid waste, wastewater, packing waste fabric and accessories and fuel are the primary sources in emitting the GHG emission in the apparel sector within various life cycle stages. Therefore, the study found various potential strategies to reduce CFP in the apparel sector, focusing on raw material-based GHG emissions, energy-based GHG emissions, solid waste-based GHG emissions, and waste water-based GHG emissions. Moreover, the study shows common strategies that will lead to reduce CFP in the apparel sector. The results from this study provide a handful of guidance to apparel sector stakeholders, other industry stakeholders, non-governmental organisations (NGOs) and other relevant authorities to address the CFP in the manufacturing industry.

Keywords: *Apparel Sector; Carbon Emission; Carbon Footprint; Climate Change.*

1. INTRODUCTION

Climate change is defined as a shift in the climate that can be directly or indirectly linked to human activity and goes beyond natural climate variability witnessed over comparable periods (United Nations, 1992). With the discussion of climate change, the sustainable development requirements concept was introduced and development that satisfies current requirements while not jeopardizing the ability of future generations to satisfy their own needs can be defined as sustainable development (World Commission on Environment and Development, 1987). Global warming is the leading cause of this deteriorating environmental situation (Mikhaylov et al., 2020). The phenomenon known as "global warming" has been going on for a while, but it results from both natural and human-

[1] Department of Building Economics, University of Moratuwa, Sri Lanka, sandaruwantharindu12@gmail.com
[2] Department of Building Economics, University of Moratuwa, Sri Lanka, anuradha@uom.lk
[3] Department of Building Economics, University of Moratuwa, Sri Lanka, grnbld17@gmail.com

caused processes (Mella, 2022). However, the constant rise in atmospheric GHG is the main underlying reason for global warming (Muhardi et al., 2020; Tumpa et al., 2019).

These GHG emissions often reach the atmosphere due to numerous industrial activities (Akhtar et al., 2017; Jia et al., 2020). The increased scales of manufacturing and advancements in automation in industries have amplified the levels of GHG in the environment (Prerna & Charu, 2018; Zhang & Chen, 2019; Zhu et al., 2018). Among them, the textile and related industry stands out as having a more significant environmental impact and causing greater environmental damage (Akhtar et al., 2017; Zhou et al., 2022). The apparel sector is heavily criticized for having adverse environmental effects across its supply chain operations (e.g., waste generation, resource consumption, carbon footprint) (Niinimäki et al., 2020). The production of textiles and clothing uses a lot of energy, water, and other natural resources, quickly producing much waste (Gupta et al., 2020). According to Akhtar et al. (2017), the apparel sector emitted 19.8 tons of carbon into the atmosphere individually. In addition to that, Okafor et al. (2021) stated that the apparel sector is now the second-largest industrial polluter behind the oil industry in the manufacturing sector, contributing 10% of the world's carbon emissions (Guru et al., 2022; Islam et al., 2020). Therefore, stakeholders of the apparel industry give more attention to taking measures for the reduction of carbon emissions (Gunathilaka & Gunewardena, 2014). Hence, various studies have been done in the apparel sector in terms of environmental sustainability of textiles and apparel: A review of evaluation methods (Luo et al., 2021), life cycle environmental impacts of the apparel industry in Sri Lanka: analysis of the energy sources (Muthukumarana et al., 2018), blockchain enhanced emission trading framework in fashion apparel manufacturing industry (Fu et al., 2018), analysis of carbon-off setting targets towards sustainable economic development in apparel sector organization in Sri-Lanka (Gunathilaka & Gunewardena, 2014), carbon emission evaluation based on the multi-objective balance of sewing assembly line in the apparel industry (Zhang & Chen, 2019) and analysing the barriers to green apparel manufacturing implementation (Guo, 2022), etc. Yet, there is no review was carried out for the management of carbon footprint in the apparel industry. Therefore, this paper aims to explore the management of carbon footprint (CFP) in the apparel industry globally using a systematic literature review approach. The paper is structured as follows. First, it provides the steps of the methodology approach. Next, research findings are based on a systematic literature review. Finally, it is followed by the conclusions and way forward.

2. METHODOLOGY

A thorough examination of the literature assists in gaining essential insights from earlier research by analysing and comprehending the relevant topics (Saunders et al., 2017). Systematic reviews, like Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), are meticulous investigations that compile all relevant data that meets a predetermined set of eligibility requirements to examine a particular area of interest (Sohrabi et al., 2021). For example, the PRISMA guideline is a four-phased flow diagram that moves through identification, screening, eligibility, and inclusion (Benachio et al., 2020).

2.1 SEARCH STRATEGY

In the initial phase, the research question of "How to manage the carbon footprint in the apparel sector" was developed using the PICO (Population, Intervention, Comparator, and Outcomes) approach (Aslam & Emmanuel, 2010). Using the terms in the research question to define the keywords for the literature survey is made possible by the PICO technique (Damsari et al., 2022). However, depending on the kind of study issue, a comparison may not always be necessary or acceptable (Hewitt-Taylor, 2017) because there is no comparator to compare with the intervention in the research question; the Comparator (C) component was ignored in this study. Accordingly, the identification of the PICO components of the research question created for the study is shown in table 1.

Table 1: PICO elements of the research question

Population	Intervention	Comparator	Outcomes
Apparel Sector	Carbon footprint	-	Management

A simple logic grid was created to conduct an initial search to find the pertinent key and index terms to include in the thorough search strategy based on the identified PICO elements of the research question. Table 2 presents the fundamental logic grid with the alternate terms for the PICO elements.

Table 2: Logic grid with identified keywords added

Population	Intervention	Comparator	Outcomes
Apparel Sector	Carbon footprint		Management
Apparel Industry	Green House Gas*		Impact*
Textile Sector	Carbon Emission*		Assessment
Textile Industry	GHG*		Feasibility
	CO_2		Evaluation
	Climate Change		Minimisation
	Environment*		Analysis
	Sustainabl*		Appraisal
			Challeng*
			Barrier*

As indicated in Table 2, wild card characters ('*') were introduced to several terms to maximise the search results in literature databases. When creating the final search strategy, quotation marks were utilised to extract the exact term, the PICO elements were combined using the Boolean operator "AND," and the detected synonyms for each element were linked using the "OR" operator. The final search string was created as follows:

("apparel sector" OR "apparel industry" OR "textile sector" OR "textile industry") AND ("carbon footprint" OR "greenhouse gas*" OR "carbon emission*" OR GHG* CO_2 OR "climate change" OR environment* OR sustainabl*) AND (Management OR Impact* OR Assessment OR Feasibility OR Evaluation OR Minimisation OR Analysis OR Appraisal OR Challeng* OR Barrier*)

The search method was modified once the last search was completed by choosing appropriate filters under the search fields, publication year, subject/research area, document type, and language as shown in Table 3.

Table 3: Filters assigned for the literature search

Categories	Filters
Search Fields	Title, Abstract, Keywords
Publication Year	From January - 2018 to January - 2023
Document	Journal Article, Conference paper
Type Language	English

2.2 STUDY SELECTION

It is advisable to use several databases while looking for pertinent references in systematic reviews. Unfortunately, because search algorithms' syntax varies depending on the database, searching databases is complicated and time-consuming (Bramer et al., 2017). Accordingly, two highly regarded databases, such as Scopus and Web of Science, were used for the search. With over 49 million registered users and 20,000 magazines from over 5,000 publishers, Scopus is the largest abstract and citation database of peer-reviewed literature (de Sousa Jabbour et al., 2019). In addition, it houses the most extensive corpus of research in several academic subjects, including science, medicine, technology, social sciences, the arts, and humanities (Fahimnia et al., 2015), and it is the most peer-reviewed database in the world (Dangelico, 2016). Furthermore, Coletta et al. (2021) stated that databases made searching literature in various worldwide scientific journals and prestigious conference proceedings possible. Therefore, Scopus and Web of Science are selected as appropriate for retrieving reviewed articles for conducting a systematic literature review.

2.3 DATA EXTRACTION

In the initial phase of the database search, 1,912 records were found, consisting of 158 from Scopus and 1,754 from the Web of Science. After further removal of 89 records duplicates, a total of 1823 records remained. Based on publication year (January -2018 to January - 2023), type of document (Journal articles and conference proceedings), and the language of the document (English), 771 records were excluded. Studies that did not include the specific CFP in apparel sector topics were 926 and excluded. From the remaining 126 records, “03 records” were excluded due to the non-availability of access to the entire paper. Further, after carefully and thoroughly reviewing in relevance to our criteria and research questions, 88 records were further excluded. Finally, the eligibility assessment resulted in a total of 35 publications in this study's systematic literature review. The PRISMA flow diagram in figure 1 illustrates the procedure modified to extract pertinent information from records obtained through structured searches conducted in bibliographic databases (Liberati et al., 2009).

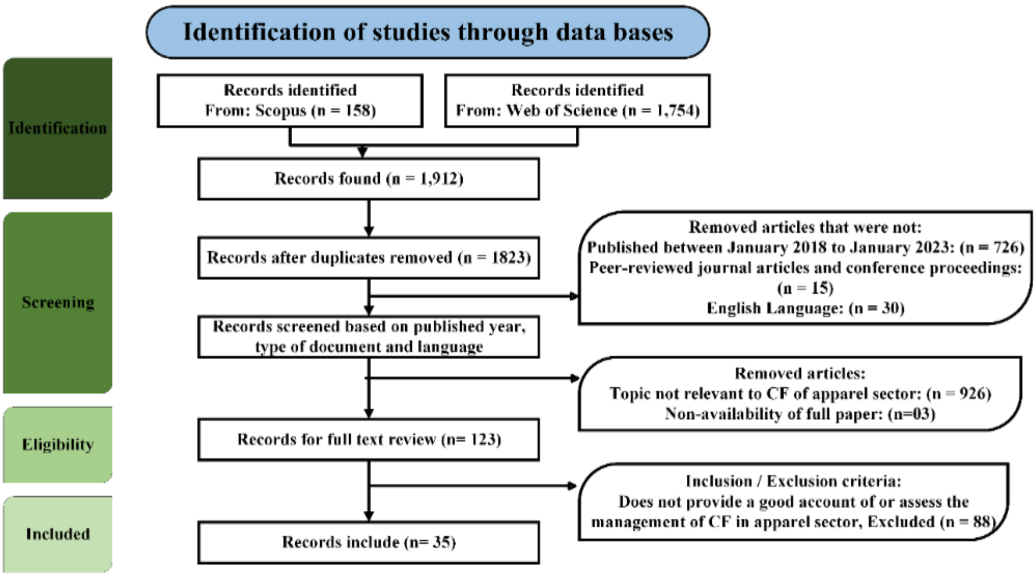

Figure 1: PRISMA flow diagram of the study

3. FINDINGS

3.1 General Observation

The chronology reflects the rapid growth of interest in CFP in the apparel sector as 29 articles of 35 articles were published in the last three years (6 in 2020, 7 in 2021, and 16 in 2022). Many publications (n = 19) have been focusing on Asia, reflecting a substantial interest in Asia, where the industry has more focus on CFP, as Asia is the main hub of the textile and apparel sector. Ten out of 19 articles in Asia have been published in China. Since, China has the world's largest textile industry and thus plays an important role in the global textile chain (Peng et al., 2022) and CFP in the global apparel sector (Lin et al., 2018a). There is an increasing focus on the global apparel sector in recent times (n = 10). However, there are only a limited number of studies from Spain (n=01), Portugal (n=01), France (n=01), Ethiopian (n=01), UK (n=01), Sri Lanka (n=01), Thailand (n=01), Bangladesh (n=01) and Chile (n=01). Accordingly, the growth of CFP in apparel sector literature concerning publication year and the region has recently increased. In the distribution of papers, 33 articles out of 35 appeared in 27 journals and the other 2 articles are from conference proceedings. Furthermore, 24 articles (72.72%) out of 33 articles appeared in 19 environmental management journals. Most articles published in environment management journals include the *Journal of Cleaner Production* (05), *Science of the Total Environment* (02), and each other journal published one article respectively.

3.2 Sources of GHG Emission in the Apparel Sector - Cradle to End

13 out of the 35 studies that were assessed talked about the CFP of the apparel industry at different life cycle stages. Table 4 shows the life cycle stages and the associated carbon emissions sources included in the research.

Table 4: GHG emission sources in the apparel sector (Cradle to End)

Life Cycle Stage	Sources of GHG Emission	References
Raw material extraction	Energy	[1], [2], [3]
	Solid waste	[1], [3], [4], [5], [6]
	Wastewater	[1], [3]
Industrial manufacturing	The chemical process of textiles	[1], [7]
	Energy	[1], [7], [8], [9], [10], [11]
	Wastewater	[1], [3]
	Solid waste	[1], [4], [5], [6], [12], [13]
Transportation (within the country)	Fuel	[1], [8]
	Packing waste at the end of the production chain	[1], [4], [5]
Consumer use	Energy	[1]
	Water	[1], [3]
	Packing waste (cartons)	[1], [5]
End-of-life disposal	Solid Waste	[1], [4], [5], [6], [8]
	Energy for Recycle	[1], [4], [5], [6], [8]

[1] (Luo et al., 2022), [2] (Ozturk et al., 2020), [3] (Qian et al., 2021), [4] (Mishra et al., 2022), [5] (Nunes et al., 2018), [6] (Zhou et al., 2022), [7] (Zhang & Chen, 2019), [8] (Espinoza Pérez et al., 2022), [9] (Jaitiang et al., 2019), [10] (Lin et al., 2018), [11] (Zhou, 2021), [12] (Bizuneh & Tadesse, 2022), [13] (Stefan et al., 2022)

Luo et al. (2022) revealed that raw material extraction, industrial manufacturing, transportation (within the country), consumer use, and end-of-life disposal are the main life cycle stages in the apparel sector. Payet (2021) stated that the raw material extraction phase is the highest GHG emission stage. Industrial manufacturing is the apparel sector's second-largest GHG emission phase (Zhang & Chen, 2019). Energy mainly contributes to the industrial manufacturing phase GHG emission (Espinoza Pérez et al., 2022; Jaitiang et al., 2019; Luo et al., 2022; Zhang & Chen, 2019). However, limited studies have been carried out to manage the energy in the apparel sector (Ozturk et al., 2020). According to previous studies, textile waste plays a significant impact on the GHG emission, and in each LCS stage, waste produced (Bizuneh & Tadesse, 2022; Luo et al., 2022; Mishra et al., 2022; Nunes et al., 2018; Stefan et al., 2022; Zhou et al., 2022). Only 15% of these textile goods are recycled after use, with more than 66% going to landfills (Shirvanimoghaddam et al., 2020). Therefore, it significantly impacted the GHG emission and environmental aspects (Stefan et al., 2022). Moreover, wastewater can be identified as another significant GHG emission source produced by the apparel sector (Bailey et al., 2022; Luo et al., 2022; Qian et al., 2021; Wang et al., 2022).

3.3 STRATEGIES TO MINIMIZE GHG EMISSIONS IN THE APPAREL SECTOR

The control of greenhouse gases has gained importance as global warming has received more attention, particularly in the textile industry (Zhu et al., 2018). Accordingly, 19 articles out of 35 elaborated on the strategies that can be led to minimizing the GHG emission in the apparel sector in some of the LCS. The summary of the strategies to minimise CFP in the apparel sector is shown in Table 5.

Table 5: Strategies to minimize CFP in the apparel sector

Strategies	References
To elaborate eco-design of the product, including the circular economy	[7], [12]
Using new raw materials that have a less environmental impact	[8]
Targeting energy saving in fabrication	[8]
PET bottle to textile	[8]
Recycled PET-based textile is an eco-friendly fabric	[8]
Processes by safe biochemical processes, which affect the properties of fibers and textiles	[8]
Use of Enzyme biocatalysts for treatment processes of fibers and textile material	[8]
Biopolymers and biomasses as new materials for surface modification of textiles	[8]
Optimization of chemical uses	[8]
Utilise environment-friendly textile dyes/substitution of input material used in a process (replacement of chemical dyes with natural dyes)	[11], [8]
Process alternatives: pulsating rinse technology	[8]
Create a new source of raw materials	[1], [2], [3], [4], [5], [8]
Additives using a valorised technique using the circular economy concept or recycle	[1], [2], [3], [4], [5], [8]
Re-use	[1], [7], [8]
Implementation of Industry 4.0 and additive manufacturing to reduce the rate of waste generation in production processes	[8]
Wastewater treatment technologies to reduce water consumption and water pollution/development of wastewater treatment on site	[7], [8], [15]
Auxiliaries to mitigate water eutrophication	[7], [15]
Water recycling and re-use	[8]
Development of high-performance membrane Nano reactor for textile wastewater treatment	[8]
Use clean energy / renewable energy generation / low-carbon electricity	[7], [9], [10], [11], [12], [13], [14], [17]
Lowering the processes temperature for energy saving	[8]
Using automated dosing machines and controllers for production	[8]
Modification of technology/equipment	[8], [18]
To reduce unsold items	[7]
Development of enzyme systems and extending their applications in surface treatment for functionalization of textile substrates	[8]
Multifunctionality of the Textile for use in more comprehensive applications: intelligent textiles.	[8]
Introduce GHG management commitment and policy	[16]
Introduce GHG management target and program	[16]
Switching to high-efficiency equipment and waste heat recovery	[17]
Increase the technical inputs, significantly increase research and development (R & D) expenditures	[18]
Accelerate the elimination of backward production capacity	[18]
Improve the relevant legal system	[12], [19]

[1] (Bizuneh & Tadesse, 2022), [2] (Leal et al., 2022), [3] (Mishra et al., 2022), [4] (Stefan et al., 2022), [5] (Zhou et al., 2022), [7] (Payet, 2021), [8] (Shirvanimoghaddam et al., 2020), [9] (Espinoza Pérez et al., 2022), [10] (Ozturk et al., 2020), [11] (Qian et al., 2021), [12] (Zhou, 2021), [13] (Chang & Zhu, 2022), [14] (Peng et al., 2022), [15] (Wang et al., 2022), [16] (Zhu et al., 2018), [17] (Jaitiang et al., 2019), [18] (Lin et al., 2018), [19] (Chang & Zhu, 2022)

All 19 articles above have provided 32 strategies to minimise CFP in the apparel sector. Out of the 19 articles, Shirvanimoghaddam et al. (2020) study provided 19 strategies, and that study can be identified as the most solutions provided article. However, 11 of 32 strategies focus on minimizing the CFP in the raw material extraction phase. These strategies are to using of new raw materials in the apparel industry that have a less environmental impact, targeting energy saving in fabrication, PET bottle to textile: recycled PET-based textile is an eco-friendly fabric made of recycled PET, processes by safe biochemical processes, which affect the properties of fibers and textiles, use of Enzyme biocatalysts for treatment processes of fibers and textile material, biopolymers and biomasses as new materials for surface modification of textiles, optimization of chemical uses, utilize environment-friendly textile dyes, the substitution of input material used in a process (replacement of chemical dyes with natural dyes), process alternatives: pulsating rinse technology (Shirvanimoghaddam et al., 2020). and elaborate product eco-design, including the circular economy (Payet, 2021). Zhou (2021) stated that the government should strengthen the top-level design to reduce environmental impact.

Furthermore, Shirvanimoghaddam et al. (2020) revealed that bamboo, silk, and hemp are the new raw materials in the apparel industry with less environmental impact. However, silk has been a material that has more than 2500 years of history. Moreover, using Internet of Things (IoT) technology for different stages of farming (smart farming) helps to minimize the CFP under the raw material extraction phase. Moreover, Mishra et al. (2022) revealed that recycled fiber also could be used as new raw materials in the apparel sector. Accordingly, studies have shown that recycling (Bizuneh & Tadesse, 2022; Leal et al., 2022; Mishra et al., 2022; Shirvanimoghaddam et al., 2020; Stefan et al., 2022; Zhou et al., 2022) and re-use (Bizuneh & Tadesse, 2022; Payet, 2021; Shirvanimoghaddam et al., 2020) are the most suitable strategies to minimized the CFP releasing through textile wastes. In addition, Shirvanimoghaddam et al. (2020) added that implementing Industry 4.0 and additive manufacturing to reduce the rate of waste generation in production processes is essential. Furthermore, Luo et al. (2022) highlighted that apparel sector stakeholder needs to focus more on water footprint in the apparel sector. The apparel sector's water footprint can also be identified as a significant CFP source (Bailey et al., 2022; Luo et al., 2022; Qian et al., 2021; Wang et al., 2022). Accordingly, studies suggested to do wastewater treatment (Wang et al., 2022), auxiliaries to mitigate water eutrophication (Payet, 2021; Wang et al., 2022), water recycling and re-use and development of high-performance membrane Nano reactor for textile wastewater treatment (Shirvanimoghaddam et al., 2020) are the most suitable strategies to minimize CFP in the wastewater of apparel sector.

The studies suggested that using renewable energy (Chang & Zhu, 2022; Espinoza Pérez et al., 2022; Jaitiang et al., 2019; Ozturk et al., 2020; Payet, 2021; Peng et al., 2022; Qian et al., 2021; Zhou, 2021) and lowering the processes temperature for energy saving (dying, printing, finishing) (Shirvanimoghaddam et al., 2020) are the most suitable strategies to reduce CFP releasing from energy. Moreover, Shirvanimoghaddam et al. (2020) suggested that using automated dosing machines and controllers in different production steps also led to saving energy consumption. Finally, the studies shown a modification of technology/equipment (Lin et al., 2018; Shirvanimoghaddam et al., 2020) to reduce unsold items (Payet, 2021), development of enzyme systems and extending their applications in surface treatment for functionalization of textile substrates, multifunctionality of the textile for use in more comprehensive applications: smart textiles (Shirvanimoghaddam et al., 2020), introduce CFP management commitment and policy, introduce CFP management target and program (Zhu et al., 2018), switching to high-efficiency equipment and waste heat recovery (Jaitiang et al., 2019), increase the technical inputs, especially to increasing research and development (R & D) expenditures, accelerate the elimination of backward production capacity (Lin et al., 2018) and improve the relevant legal system (Chang & Zhu, 2022; Zhou, 2021) common strategies led to minimized CFP in the apparel sector.

3.4 SUMMARY

The study found that energy, solid waste, fabric and accessories waste, water, fuel, and packing waste are the primary GHG emission sources coming under various life cycle stages in the apparel sector. Therefore, based on the GHG emission sources, suitable strategies to minimise CFP in the apparel sector were found and summarised, as shown in Figure 2.

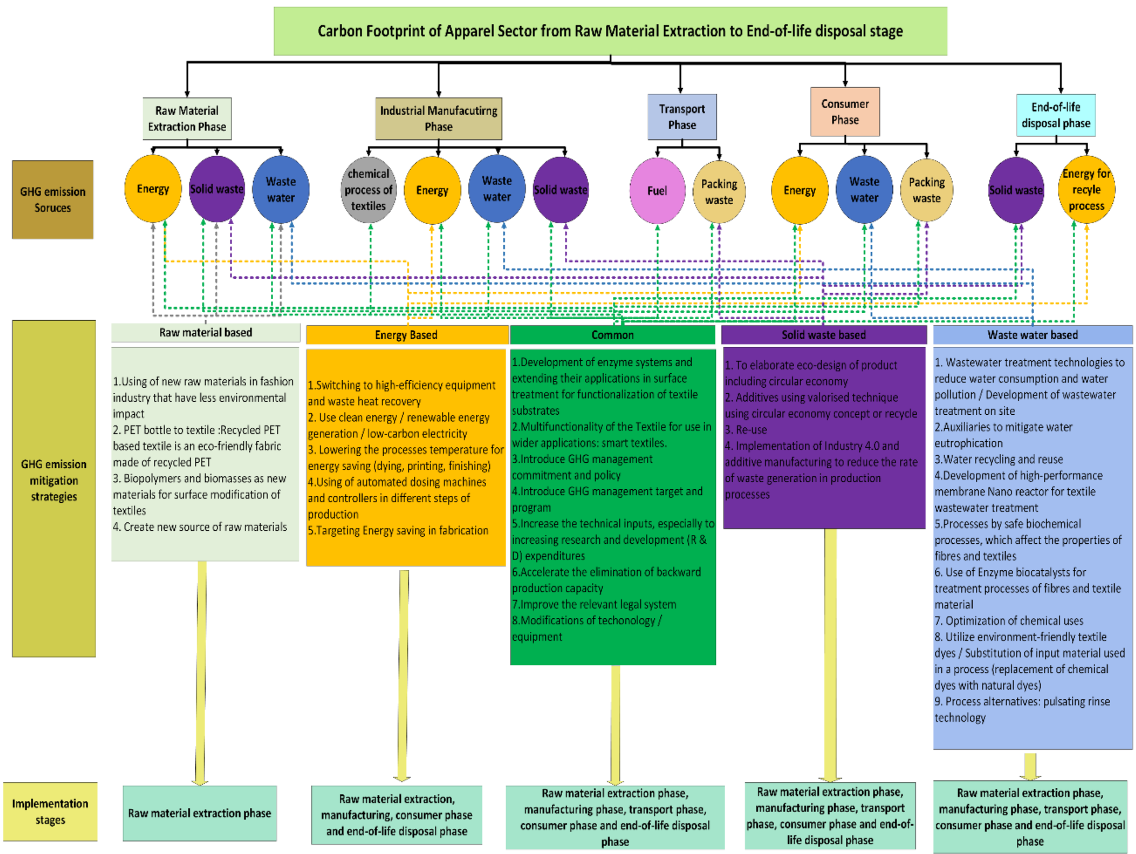

Figure 2: Summary of strategies to minimise CFP in the apparel sector (Raw material phase to end-of-life phase)

4. CONCLUSIONS AND WAY FORWARD

4.1 CONCLUSIONS

The main aim of this study was to investigate the management of CFP in the apparel sector. A systematic literature review was carried out to identify the GHG emission sources and strategies to minimise CFP in the apparel sector using PRISMA systematic analysis. Accordingly, energy, solid waste, wastewater, packing waste, the chemical process of textiles, and fuel are the primary sources emitting CO_2 and other GHG emissions at the various production stages of the apparel sector. However, the review also shows energy is a significant contributor directly and indirectly to GHG emissions in the apparel sector. The results lead to conclude that using new raw materials, switching to high-efficiency equipment, using clean energy / renewable energy generation / low-carbon electricity, elaborate eco-design of the product including circular economy, additives using a valorised technique using the circular economy concept or recycling, re-use, wastewater treatment technologies to reduce water consumption and water pollution, water recycling and re-use, optimization of chemical uses and utilize environment-friendly textile dyes/substitution of input material used in a process (replacement of chemical dyes with natural dyes are the critical potential strategies to minimize CFP emitting from wastewater in the apparel sector. Finally, the study concluded and recommended that introducing CFP management commitment and policy, introducing CFP management targets and programs, increasing the technical inputs, especially to increasing research and development (R & D) expenditures, accelerating the elimination of backward production capacity, improving the relevant legal system and modifications of technology/equipment are common strategies that will lead to reducing CFP in the apparel sector.

4.2 LIMITATIONS

This study has some limitations despite its contributions. Only the databases Scopus and Web of Science have been used for the search. Therefore, other relevant publications regarding the management of carbon footprint in the apparel industry be missing. For this reason, the research findings might not fully reflect the whole available literature on the management of carbon footprint in the apparel industry. Notwithstanding the careful selection of the relevant papers, not all keywords may have been captured in the literature search. In the review of literature, the selection of relevant papers and identification of the strategies for the management of carbon footprint in the apparel industry might have been affected by subjective judgments. The above-mentioned limitations generate fertile grounds for further research and should be considered when interpreting the findings of the research. This study recommends the use of a variety of data sets and a more extensive range of literature.

5. REFERENCES

Akhtar, S., Baig, S. F., Saif, S., Mahmood, A., & Ahmad, S. R. (2017). Five year carbon footprint of a textile industry: A podium to incorporate sustainability. *Nature Environment and Pollution Technology*, *16*(1), 125–132. http://www.neptjournal.com/upload-images/NL-59-18-(16)D-495.pdf

Aslam, S., & Emmanuel, P. (2010). Formulating a researchable question: A critical step for facilitating good clinical research. *Indian Journal of Sexually Transmitted Diseases and AIDS*, *31*(1), 47–50. https://doi.org/10.4103/0253-7184.69003

Bailey, K., Basu, A., & Sharma, S. (2022). The Environmental Impacts of Fast Fashion on Water Quality:

A Systematic Review. *Water*, *14*(7). https://www.mdpi.com/2073-4441/14/7/1073

Benachio, G. L. F., Freitas, M. do C. D., & Tavares, S. F. (2020). Circular economy in the construction industry: A systematic literature review. *Journal of Cleaner Production*, *260*. doi: 10.1016/j.jclepro.2020.121046

Bizuneh, B., & Tadesse, R. (2022). Investigation of Ethiopian apparel industry’s fabric waste and its management strategies. *Journal of the Textile InstitutE*, *113*(1), 141–150.doi: 10.1080/00405000.2020.1865509

Bramer, W. M., Rethlefsen, M. L., Kleijnen, J., & Franco, O. H. (2017). Optimal database combinations for literature searches in systematic reviews: a prospective exploratory study. *Systematic Reviews*, *6*(1), 1–12. https://doi.org/10.1186/s13643-017-0644-y

Chang, R., & Zhu, S. (2022). Probe into the Low-Carbon Economic Environment Challenges and Opportunities of Textile and Garment Export. *Journal of Environmental and Public Health*, *2022*, 1–11. https://doi.org/10.1155/2022/6043903

Coletta, L., Vainieri, M., Noto, G., & Murante, A. M. (2021). Assessing inter-organizational performance through customer value: a literature review. *Journal of Business & Industrial Marketing*, *36*(13), 15–27. https://doi.org/10.1108/JBIM-07-2020-0353

Damsari, A. G. U., Thayaparan, M., & Fernando, T. (2022). State of the Art in Risk Sensitive Urban Development: a Systematic Literature Review. In Y. G. Sandanayake, S. Gunatilake, & K. G. A. . Waidyasekara (Eds.), *World Construction Symposium* (pp. 731–742). https://ciobwcs.com/downloads/papers22/WCS2022_Proceedings_59.pdf

Dangelico, R. M. (2016). Green Product Innovation: Where we are and Where we are Going. *Business Strategy and the Environment*, *25*(8), 560–576. https://doi.org/10.1002/BSE.1886

de Sousa Jabbour, A. B. L., Chiappetta Jabbour, C. J., Sarkis, J., Gunasekaran, A., Furlan Matos Alves, M. W., & Ribeiro, D. A. (2019). Decarbonisation of operations management–looking back, moving forward: a review and implications for the production research community. *International Journal of Production Research*, *57*(15–16), 4743–4765. https://doi.org/10.1080/00207543.2017.1421790

Espinoza Pérez, L. A., Espinoza Pérez, A. T., & Vásquez, Ó. C. (2022). Exploring an alternative to the Chilean textile waste: A carbon footprint assessment of a textile recycling process. *Science of the Total Environment*, *830*. https://doi.org/10.1016/j.scitotenv.2022.154542

Fahimnia, B., Sarkis, J., & Davarzani, H. (2015). Green supply chain management: A review and bibliometric analysis. *International Journal of Production Economics*, *162*, 101–114. https://www.researchgate.net/publication/271517931_Green_Supply_Chain_Management_A_Review_and_Bibliometric_Analysis

Fu, B., Shu, Z., & Liu, X. (2018). Blockchain Enhanced Emission Trading Framework in Fashion Apparel Manufacturing Industry. *Sustainability*, *10*(4), 1105. https://www.mdpi.com/2071-1050/10/4/1105

Gunathilaka, D., & Gunewardena, K. (2014). Analysis of Carbon-off Setting Targets towards Sustainable Economic Development in Apparel Sector Organization in Sri-Lanka. *International Journal of Trade, Economics and Finance*, *5*(4), 360–363. https://doi.org/10.7763/IJTEF.2014.V5.398

Gunathilaka, L. F. D. D. Z., & Gunewardena, K. D. (2014). Analysis of Carbon-off Setting Targets towards Sustainable Economic Development in Apparel Sector Organization in Sri-Lanka. *International Journal of Trade, Economics and Finance*, *5*(4), 3–6. http://www.ijtef.org/papers/398-L1010.pdf

Guo, H. L. (2022). Analysing the barriers to green apparel manufacturing implementation. *Journal of Fashion Marketing and Management*. https://doi.org/10.1108/JFMM-09-2021-0226

Gupta, V., Arora, M., & Minhas, J. (2020). Innovating Opportunities for Fashion Brands by Using Textile Waste for Better Fashion. In P. Pandit, S. Ahmed, K. Singha, & S. Shrivastava (Eds.), *Recycling from Waste in Fashion and Textiles* (pp. 101–121). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781119620532.CH5

Guru, R., Grewal, D., & Thennarasu, P. (2022). Explores the role of fast fashion in sustainability: stylish killer for the environment. *Journal of Textile Engineering & Fashion Technology*, *8*(3), 59–63. https://medcraveonline.com/JTEFT/JTEFT-08-00302.pdf

Hewitt-Taylor, J. . (2017). *The Essential Guide to Doing a Health and Social Care Literature Review* (2nd ed.). Routledge. https://books.google.com/books?hl=en&lr=&id=1DklDwAAQBAJ&oi=fnd&pg=PP1&dq=The+Esse

ntial+Guide+to+Doing+a+Health+and+Social+Care+Literature+Review&ots=znTRuUZwYp&sig=5L_aPxNIbH72izHrDj7qMIuikCU

Islam, S., Ahmed, S., Parvin, F., Urmy, Z., & Islam, A. . (2020). A Study on the Solutions of Environment Pollutions and Worker's Health Problems Caused by Textile Manufacturing Operations. *Journal of Scientific and Technical Research*, *28*(4), 21831–21844. https://www.researchgate.net/profile/Shaharia-Ahmed-3/publication/355778898_A_Study_on_the_Solutions_of_Environment_Pollutions_and_Worker's_Health_Problems_Caused_by_Textile_Manufacturing_Operations/links/617d55dca767a03c14d1ae28/A-Study-on-the-Solutions-of-Environment-Pollutions-and-Workers-Health-Problems-Caused-by-Textile-Manufacturing-Operations.pdf

Jaitiang, T., Vorayos, N., & Deethayat, T. (2019). Energy conservation tracking of Thailand's energy and GHG mitigation plan: A case of Thailand's textile industry. *Energy Reports*, *6*, 467–473. doi: 10.1016/j.egyr.2019.11.104

Jia, F., Yin, S., Chen, L., & Chen, X. (2020). The circular economy in the textile and apparel industry: A systematic literature review. *Journal of Cleaner Production*, *259*, 1–20. doi: 10.1016/j.egyr.2019.11.104

Leal, W., Perry, P., Heim, H., Dinis, M. A. P., Moda, H., Ebhuoma, E., & Paco, A. (2022). An overview of the contribution of the textiles sector to climate change. *Frontiers In Environmental Science*, *10*. doi: 10.3389/fenvs.2022.973102

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., Clarke, M., Devereaux, P. J., Kleijnen, J., & Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. *Journal of Clinical Epidemiology*, *62*(10), 34.doi: 10.7326/0003-4819-151-4-200908180-00136

Lin, B., Chen, Y., & Zhang, G. (2018). Impact of technological progress on China's textile industry and future energy saving potential forecast. *Energy*, *161*, 859–869. doi: 10.1016/j.energy.2018.07.178

Luo, Y., Song, K., Ding, X., & Wu, X. (2021). Environmental sustainability of textiles and apparel: A review of evaluation methods. *Enviornmental Impact Assesment Review*, *86*, 106497.doi: 10.1016/j.eiar.2020.106497

Luo, Y., Wu, X., & Ding, X. (2022). Carbon and water footprints assessment of cotton jeans using the method based on modularity: A full life cycle perspective. *Journal of Cleaner Production*, *332*, 1–15. doi: 10.1016/j.jclepro.2021.130042

Mella, P. (2022). Global Warming: Is It (Im)Possible to Stop It? The Systems Thinking Approach. *Energies*, *15*(705), 1–33. https://doi.org/10.3390/en15030705

Mikhaylov, A., Moiseev, N., Aleshin, K., & Burkhardt, T. (2020). Global climate change and greenhouse effect. *Enterpreneurship and Sustainability Issues*, *7*(4), 2897–2913. doi: 10.9770/jesi.2020.7.4(21)

Mishra, P. K., Izrayeel, A. M. D., Mahur, B. K., Ahuja, A., & Rastogi, V. K. (2022). A comprehensive review on textile waste valorization techniques and their applications. *Environmental Science and Pollution Research*, *29*(44), 65962–65977. doi: 10.1007/s11356-022-22222-6

Muhardi, M., Cintyawati, C., Adwiyah, R., Hami, N., Hashim, R., Omar, S., & Shafie, S. M. (2020). The Implementation of Sustainable Manufacturing Practice in Textile Industry: An Indonesian Perspective. *Journal of Asian Finance Economics and Business*, *7*(11), 1041–1047. doi: 10.13106/jafeb.2020.vol7.no11.1041

Muthukumarana, T. T., Karunathilake, H. P., Punchihewa, H. K. G., & Manthilake, M. M. I. D. (2018). Life cycle environmental impacts of the apparel industry in Sri Lanka : Analysis of the energy sources. *Journal of Cleaner Production*, *172*, 1346–1357. doi: 10.1016/j.jclepro.2017.10.261

Niinimäki, K., Peters, G., Dahlbo, H., Perry, P., Rissanen, T., & Gwilt, A. (2020). The environmental price of fast fashion. *Nature Reviews Earth & Environment* , *14*, 189–200. doi: 10.1038/s43017-020-0039-9

Nunes, L. J. R., Godina, R., Matias, J. C. O., & Cataldo, J. P. S. (2018). Economic and environmental benefits of using textile waste for the production of thermal energy. *Journal of Cleaner Production*, *171*, 1353–1360. https://doi.org/10.1016/j.jclepro.2017.10.154

Okafor, C. C., Madu, C. N., Ajaero, C. C., Ibekwe, J. C., & Nzekwe, C. A. (2021). Sustainable management of textile and clothing. *Clean Technologies and Recycling*, *1*(1), 70–87.doi: 10.3934/ctr.2021004

Ozturk, E., Cinperi, N. C., & Kitis, M. (2020). Improving energy efficiency using the most appropriate techniques in an integrated woolen textile facility. *Journal of Cleaner Production*, *254*. doi: 10.1016/j.jclepro.2020.120145

Payet, J. (2021). Assessment of carbon footprint for the textile sector in France. *Sustainability*, *13*(5), 1–23. https://doi.org/10.3390/su13052422

Peng, S.-Y., Liu, J.-Y., & Geng, Y. (2022). Assessing Strategies For Reducing The Carbon Footprint Of Textile Products In China Under The Shared Socioeconomic Pathways Framework. *Climate Change Economics*, *13*(1). https://doi.org/10.1142/S2010007822400048

Prerna, J., & Charu, G. (2018). The story of textile waste- Reasons and solutions. *International Journal of Applied Home Science*, *5*(4), 871–890. http://scientificresearchjournal.com/wp-content/plugins/download-attachments/includes/download.php?id=3008

Qian, W., Ji, X., Xu, P., & Wang, L. (2021). Carbon footprint and water footprint assessment of virgin and recycled polyester textiles. *Textile Research Journal*, *91*(21–22), 2468–2475.doi: 10.1177/00405175211006213

Saunders, M., Lewil, P., & Thornhill, A. (2017). *Research Methods for Business Students* (5th ed.). Pearson Education Limited, England. https://books.google.com/books/about/Research_Methods_for_Business_Students.html?id=43wDBmAKzA4C

Shirvanimoghaddam, K., Motamed, B., Ramakrishna, S., & Naebe, M. (2020). Death by waste: Fashion and textile circular economy case. *Science of The Total Environment*, *718*, 1–10. doi: 10.1016/j.scitotenv.2020.137317

Sohrabi, C., Franchi, T., Mathew, G., Kerwan, A., Nicola, M., Griffin, M., Agha, M., & Agha, R. (2021). PRISMA 2020 statement: What's new and the importance of reporting guidelines. *International Journal of Surgery*, *88*, 39–42. doi: https://doi.org/10.1016/j.ijsu.2021.105918

Stefan, D. S., Bosomoiu, M., & Stefan, M. (2022). Methods for Natural and Synthetic Polymers Recovery from Textile Waste. *Polymers*, *14*(19). https://doi.org/10.3390/polym14193939

Tumpa, T. J., Ali, S. M., Rahman, M. H., Paul, S. K., Chowdhury, P., & Khan, S. A. R. (2019). Barriers to green supply chain management: An emerging economy context. *Journal of Cleaner Production*, *236*. https://doi.org/10.1016/j.jclepro.2019.117617

United Nations. (1992). *United Nations Framework Convention on Climate Change (New York)*. GE.05-62220 https://unfccc.int/resource/docs/convkp/conveng.pdf

Wang, X. X., Jiang, J. M., & Gao, W. J. (2022). Reviewing textile wastewater produced by industries: characteristics, environmental impacts, and treatment strategies. *Water Science & Technology*, *85*(7), 2076–2096. https://doi.org/10.2166/wst.2022.088

World Commission on Environment and Development. (1987). *Our common future*. file:///C:/Users/User/Downloads/our_common_futurebrundtlandreport1987.pdf

Yang, Y., Guo, Y. Q., Zhu, W. S., & Huang, J. B. (2019). Environmental impact assessment of China's primary aluminum based on life cycle assessment. *Transactions of Nonferrous Metals Society of China*, *29*(8), 1784–1792. https://doi.org/10.1016/S1003-6326(19)65086-7

Zhang, X. J., & Chen, Y. (2019). Carbon Emission Evaluation Based on Multi-Objective Balance of Sewing Assembly Line in Apparel Industry. *Energies*, *12*(14). doi: 10.3390/en12142783

Zhou, L. (2021). Need for development of low carbon economy in China using analysis of Guangdong textile industry as case study. *E3S Web of Conferences*, *300*. https://doi.org/10.1051/e3sconf/202130002006

Zhou, Q., Le, Q. V, Meng, L., Yang, H., Gu, H., Yang, Y., Chen, X., Lam, S. S., Sonne, C., & Peng, W. (2022). Environmental perspectives of textile waste, environmental pollution and recycling. *Environmental Technology Reviews*, *11*(1), 62–71. https://doi.org/10.1080/21622515.2021.2017000

Zhu, L. S., Chen, L. Z., Wu, X. Y., & Ding, X. M. (2018). Developing a greenhouse gas management evaluation system for Chinese textile enterprises. *Ecological Indicators*, *91*, 470–477. doi: 10.1016/j.ecolind.2018.04.029