GLOBAL MAINSTREAM JOURNAL OF BUSINESS, ECONOMICS, DEVELOPMENT & PROJECT MANAGEMENT

Vol. 01, No. 01, September, 2022
e-ISSN: **2998-3746**

REDUCING CARBON EMISSIONS IN THE FASHION AND TEXTILE INDUSTRY THROUGH SUSTAINABLE PRACTICES AND RECYCLING: A PATH TOWARDS A CIRCULAR, LOW-CARBON FUTURE

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Keywords

Sustainable Practices
Carbon Reduction
Textile Industry
Circular Economy
Recycling Techniques

Doi

10.62304/jbedpm.v1i1.226

ABSTRACT

The fashion and textile industry is a major contributor to global greenhouse gas emissions, resource depletion, and environmental degradation. While sustainable fashion initiatives have gained momentum in recent years, the industry continues to face challenges in achieving widespread adoption of environmentally responsible practices. This study conducts a systematic literature review of 92 peer-reviewed articles following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to examine consumer behavior, eco-labeling effectiveness, fast versus slow fashion consumption, psychological influences, and the role of brands in promoting sustainability. The findings reveal a persistent attitude-behavior gap, where increased consumer awareness of sustainability issues does not consistently translate into sustainable purchasing behavior due to factors such as affordability, accessibility, and skepticism towards corporate green claims. While eco-labeling and green marketing strategies can positively influence consumer preferences, their effectiveness is often diminished by consumer confusion and distrust stemming from greenwashing practices and an overwhelming number of certification schemes. The study also highlights the continued dominance of fast fashion, driven by low prices, rapid trend cycles, and social media influence, making it difficult for slow fashion models to compete. Psychological factors such as social identity, peer influence, and perceived behavioral control emerge as significant determinants of sustainable fashion choices, emphasizing that social and emotional motivators play a key role in shaping consumer behavior. Additionally, while fashion brands have the potential to educate consumers on sustainability, the study finds that a lack of regulatory oversight and standardized sustainability benchmarks undermines consumer trust, limiting the impact of brand-led sustainability initiatives. The review underscores the need for a multi-faceted approach to drive meaningful change, including stronger regulatory frameworks, enhanced consumer education, economic incentives, and greater industry transparency. The transition toward sustainable fashion consumption requires a collective effort from policymakers, brands, and consumers to create a system where sustainability is both a viable and desirable option. This study contributes to the growing body of literature by synthesizing key trends, challenges, and opportunities in sustainable fashion, providing insights that can inform future research and policy interventions aimed at fostering a more sustainable textile industry.

Received: 26, July, 2022 |**Accepted**: 27, September 2022 |**Published**: 29, September, 2022

GLOBAL MAINSTREAM JOURNAL OF BUSINESS, ECONOMICS, DEVELOPMENT & PROJECT MANAGEMENT
Vol. 1, No. 01, September, 2022, **Page**: 57-76

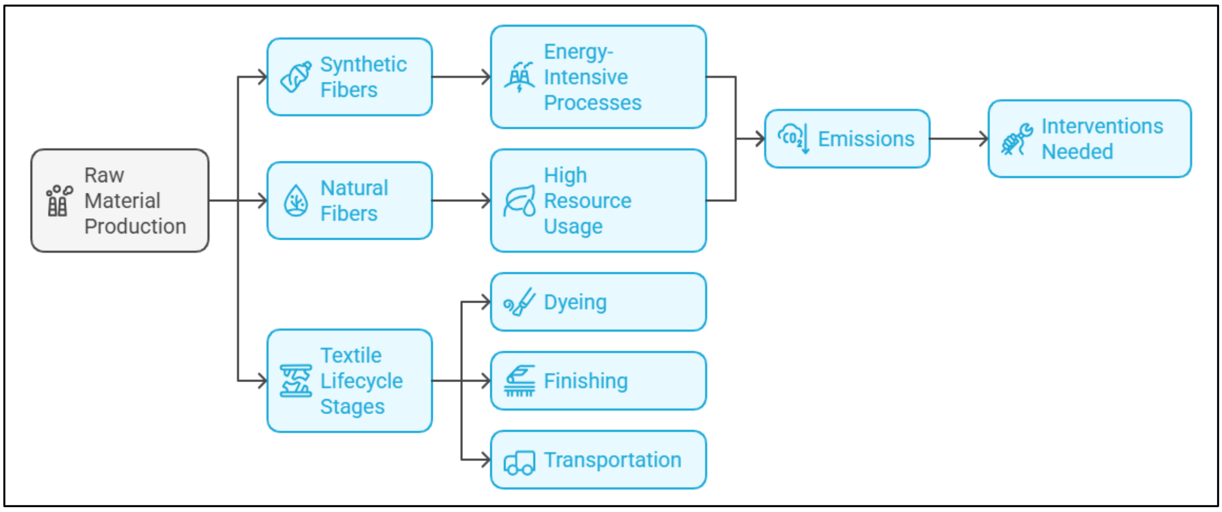
1 INTRODUCTION

The fashion and textile industry is recognized as one of the most resource-intensive and environmentally impactful sectors globally, responsible for a significant proportion of carbon emissions and waste generation (Eriksson, 2016). The industry's environmental footprint stems from energy-intensive production processes, the extraction and processing of raw materials, and the disposal of textile waste (Leal Filho et al., 2022). According to Corvellec and Stål (2019), the global textile industry emitted approximately 1.2 billion tons of greenhouse gases in 2017, which is more than the emissions generated by international flights and maritime shipping combined. The dominance of fast fashion, characterized by rapid production cycles and disposable consumer behavior, has exacerbated environmental degradation, with studies reporting a direct correlation between the rise of fast fashion and the increase in textile waste and carbon emissions (Nadagouda et al., 2020). These alarming statistics underline the urgency of adopting sustainable practices in the textile industry to mitigate its environmental impact (Pickering et al., 2016).

One of the most critical areas contributing to the carbon footprint of the fashion industry is the raw material production stage, accounting for the majority of greenhouse gas emissions (Weiss et al., 2012). Synthetic fibers such as polyester, derived from petrochemical processes, are particularly energy-intensive and result in significant emissions (Warasthe et al., 2022). Even natural fibers, such as cotton, contribute to environmental challenges due to the high water and pesticide usage involved in their cultivation (Shirvanimoghaddam et al., 2019). In addition, the life cycle of textile products encompasses stages such as dyeing, finishing, and transportation, all of which further contribute to emissions (Muñoz-Torres et al., 2020). Studies by Okedu et al. (2022) and Wang et al. (2016) emphasize that the cumulative emissions from the textile production chain necessitate interventions at every stage of the product lifecycle, from raw material extraction to end-of-life management.

Recycling has emerged as a pivotal strategy for reducing the environmental footprint of textiles, with studies indicating that post-consumer textile waste accounts for a substantial proportion of landfill and incineration emissions (Wang et al., 2016; Weiss et al., 2012). Chourasiya et al. (2022) highlight the potential of circular economy practices in creating closed-loop systems where materials are reused and repurposed, thus minimizing waste. Textile recycling not only conserves resources but also significantly reduces emissions by replacing the need for virgin raw materials (Eriksson, 2016). However, effective recycling is contingent upon the development of robust waste sorting and processing infrastructure, which remains a challenge in many textile-producing countries (Raut et al., 2019). In addition to recycling, energy efficiency in textile production processes has been identified as a key area for reducing emissions. Technological advancements in processes such as molten direct spinning and waste heat recovery have demonstrated considerable potential for lowering energy consumption in textile manufacturing (Leal Filho et al., 2022; Raut et al., 2019). Similarly, the adoption of renewable energy sources in textile mills, such as solar and wind power, has been shown to significantly decrease the carbon footprint of production

Figure 1: Fashion Industry Carbon Footprint



(Haslinger et al., 2019). Studies by Chourasiya et al. (2022) and Muñoz-Torres et al. (2020) further underscore the role of energy conservation measures in reducing emissions at scale. Integrating renewable energy into production processes not only benefits the environment but also enhances the economic resilience of textile enterprises by reducing dependency on fossil fuels.

Consumer behavior also plays a pivotal role in influencing the environmental impact of the textile industry. Research suggests that consumer awareness and preferences for sustainable products can drive demand for eco-friendly materials and practices (Leal Filho et al., 2022). For instance, the Haslinger et al. (2019) advocates for fostering emotional connections with products to extend their lifespan, thereby reducing consumption and waste. Warasthe et al. (2022) and Alkaya and Demirer (2014) similarly emphasize the importance of cultivating consumer habits that prioritize quality and durability over quantity. Transparent labeling and marketing strategies, such as those that highlight the environmental benefits of bio-based or recycled materials, have proven effective in shifting consumer preferences toward sustainable options (Streit & Davies, 2017). Lastly, industry-wide collaboration and policy interventions are instrumental in promoting sustainable practices in the textile sector. Initiatives such as the establishment of industry standards and guidelines, coupled with government incentives for adopting sustainable technologies, have been effective in driving change (Hanoğlu et al., 2019). For example, carbon pricing mechanisms and emissions trading systems have been implemented in some regions to incentivize energy efficiency and emissions reduction (Raut et al., 2019). The integration of supply chain actors, including textile producers, retailers, and waste management entities, is critical for maximizing resource efficiency and achieving systemic sustainability (Haslinger et al., 2019). Collaborative efforts that prioritize resource circulation and inter-industry connectivity have the potential to redefine the textile industry as a model for low-carbon, sustainable production. The primary objective of this study is to explore and evaluate the strategies and practices that can reduce carbon emissions in the fashion and textile industry, focusing on sustainable approaches implemented before 2022. This research aims to identify critical areas of improvement across the industry's lifecycle, including raw material production, manufacturing processes, and end-of-life waste management, by synthesizing insights from existing literature. By analyzing the role of recycling frameworks, energy-efficient technologies, and renewable energy adoption, the study seeks to highlight actionable pathways for reducing the industry's environmental footprint. Furthermore, this study examines the influence of consumer behavior, policy interventions, and industry collaboration on driving sustainable practices, emphasizing the adoption of circular economy principles. Through a comprehensive evaluation of these factors, the research aspires to contribute to the understanding of effective methods for decarbonizing the textile sector, providing valuable insights for industry stakeholders and policymakers.

2 LITERATURE REVIEW

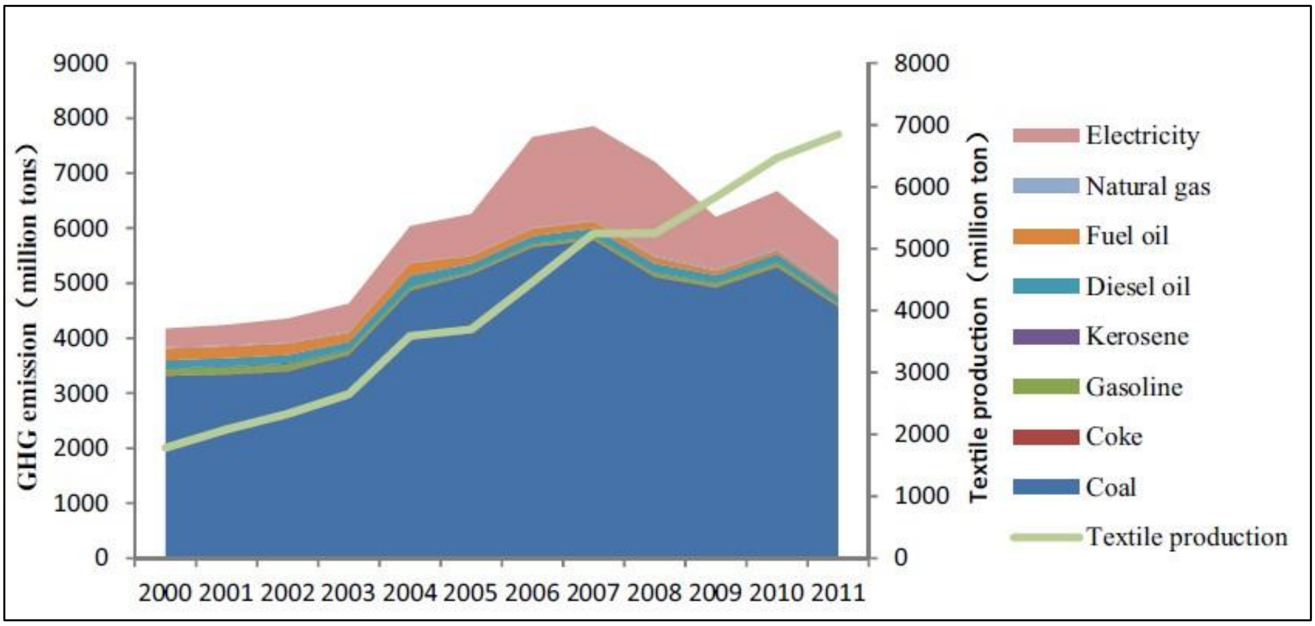
The fashion and textile industry has long been recognized as one of the most environmentally impactful sectors, primarily due to its high carbon emissions, excessive resource consumption, and unsustainable waste management practices. Existing literature extensively explores the environmental footprint of textile production, with studies highlighting the contributions of raw material extraction, manufacturing processes, and post-consumer disposal to greenhouse gas emissions. Research has also identified key mitigation strategies, including energy-efficient technologies, sustainable material innovations, and circular economy practices, aimed at reducing the carbon footprint of the industry. The integration of life cycle assessment (LCA) methods in textile production has further enabled researchers to evaluate the environmental impact of different textile types, offering data-driven insights into emission reduction strategies. As sustainability gains momentum in the global textile supply chain, a growing body of research focuses on the role of renewable energy adoption, industrial waste repurposing, and innovative recycling techniques in lowering emissions. Additionally, studies emphasize the significance of consumer behavior in driving sustainable fashion, examining the influence of eco-labeling, ethical purchasing decisions, and consumer awareness initiatives in promoting low-carbon choices. Policy and regulatory frameworks have also been explored in the literature, with research assessing the effectiveness of carbon pricing, environmental regulations, and government incentives in supporting the transition towards a more sustainable textile industry.

2.1 Global Greenhouse Gas Emissions

Greenhouse gas (GHG) emissions from the textile and fashion industry have been widely documented as a significant contributor to global climate change. The sector accounts for approximately 10% of global carbon dioxide (CO_2) emissions, making it one of the most polluting industries (Cheng & Liang, 2021). The emissions stem from energy-intensive production processes, raw material extraction, transportation, and waste disposal (Broeren et al., 2017). The life cycle of textiles, from fiber production to end-of-life treatment, involves high fossil fuel dependency, particularly in polyester production, which alone accounts for 60% of global fiber use (Semba et al., 2020). The dyeing and finishing processes further contribute to emissions due to the heavy use of synthetic chemicals and high water consumption (Gopalakrishnan et al., 2021). In China, the world's largest textile producer, carbon emissions from textile manufacturing reached 1.2 billion metric tons in 2017, highlighting the industry's role in the global carbon footprint (Benavides et al., 2020). A major concern regarding textile-related GHG emissions is the environmental impact of raw material production. Natural fibers such as cotton require intensive water use and chemical inputs, leading to significant indirect emissions (Wiedemann et al., 2016). The carbon footprint of cotton production is estimated to be 6.5 kg CO_2-equivalent per kg of fiber, largely due to fertilizer and pesticide application, which contribute to soil degradation and nitrous oxide emissions (Wren, 2022). Synthetic fibers, particularly polyester and nylon, have an even higher carbon footprint due to their derivation from petrochemicals (Shen & Patel, 2008). The production of polyester alone emits nearly three times more CO_2 per kilogram than cotton, exacerbating climate concerns (Benavides et al., 2020). Recycling synthetic fibers has been proposed as a viable solution, but studies indicate that current recycling technologies are insufficient to offset the industry's emissions at scale (Shen & Patel, 2008).

The role of energy consumption in textile production has been extensively studied, with findings indicating that over 60% of the industry’s emissions result from fossil fuel-based electricity and heating processes (Chen & Burns, 2006). High-energy processes such as spinning, weaving, dyeing, and finishing require substantial electricity and heat, typically generated from coal and natural gas (Luo et al., 2021; Sandin & Peters, 2018). Technological advancements such as molten direct spinning and waterless dyeing have demonstrated the potential to reduce emissions by increasing efficiency and reducing chemical and energy use (Dissanayake & Sinha, 2015). However, implementing energy-efficient technologies requires significant financial investment, which remains a barrier for many manufacturers, particularly in developing economies (Espinoza Pérez et al., 2022). Additionally, supply chain logistics, including the global transportation of raw materials and

Figure 2:Textile production and GHG emissions from various energy sources for the textile industry in China.



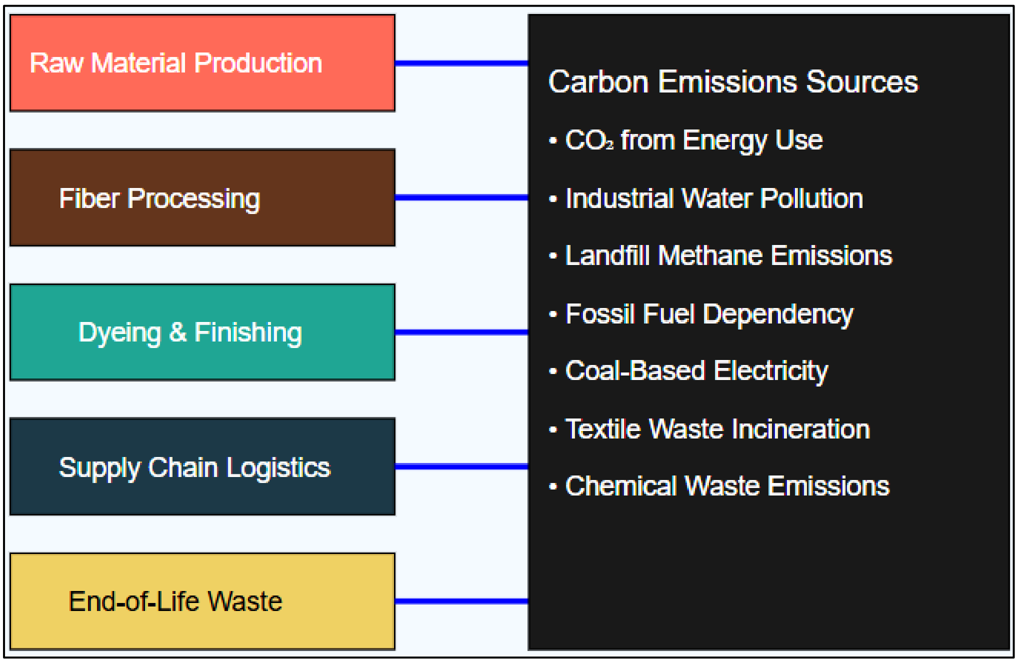
Source:Huang et al. (2016)

finished products, further exacerbate emissions, with studies showing that international shipping and air freight contribute significantly to the industry's carbon footprint (Paço et al., 2020). The management of textile waste and its role in carbon emissions has also been a key focus in the literature. Studies indicate that over 92 million tons of textile waste are generated annually, with 73% being landfilled or incinerated, leading to methane emissions and energy-intensive disposal processes (Semba et al., 2020). The circular economy model has been proposed as a means to reduce emissions by promoting textile recycling, reuse, and remanufacturing (Espinoza Pérez et al., 2022). However, inefficient textile waste sorting systems and low recycling rates continue to limit progress (Bick et al., 2018; Semba et al., 2020). Research suggests that extended producer responsibility (EPR) policies and consumer education on sustainable disposal methods could help reduce textile waste emissions (Muhardi et al., 2020). Despite the existence of sustainable alternatives, the dominance of fast fashion and its reliance on disposable clothing models remain a significant challenge in addressing the industry's carbon footprint (Yan et al., 2016).

2.2 Textile Production To Global Greenhouse Gas Emissions

The textile industry is one of the largest industrial contributors to greenhouse gas (GHG) emissions, with its impact spanning across multiple stages of the supply chain, including raw material production, fiber processing, dyeing, finishing, and transportation (Morgan & Birtwistle, 2009). The global textile sector accounts for approximately 10% of total industrial carbon emissions, surpassing emissions from international aviation and maritime shipping combined (Luo et al., 2021; Sandin & Peters, 2018). The industry's dependence on fossil fuel-based energy sources intensifies its carbon footprint, particularly in major textile-producing countries such as China, India, and Bangladesh, where coal remains a dominant energy source (Hibberd, 2020). The manufacturing of synthetic fibers, primarily polyester, releases significant carbon dioxide (CO_2) emissions, as the production of one kilogram of polyester generates more than three times the emissions of cotton (Zhang et al., 2020). The extensive use of non-renewable resources in textile production, including petrochemicals for synthetic fibers and energy-intensive processes for natural fibers, highlights the sector's major role in exacerbating global GHG emissions (Semba et al., 2020). The raw material phase of textile production significantly influences the industry's carbon emissions. Studies have identified that natural fibers such as cotton contribute substantial emissions due to excessive water use, fertilizer application, and pesticide dependence (Shen & Patel, 2008). The carbon footprint of cotton is estimated at 6.5 kg CO_2-equivalent per kilogram of fiber, mainly due to nitrogen-based fertilizers that release nitrous oxide, a potent greenhouse gas (Benavides et al., 2020). Similarly, wool and silk production generate high emissions due to methane released from livestock and

Figure 3: Contribution of Textile Production Stages to Global Greenhouse Gas (GHG) Emissions



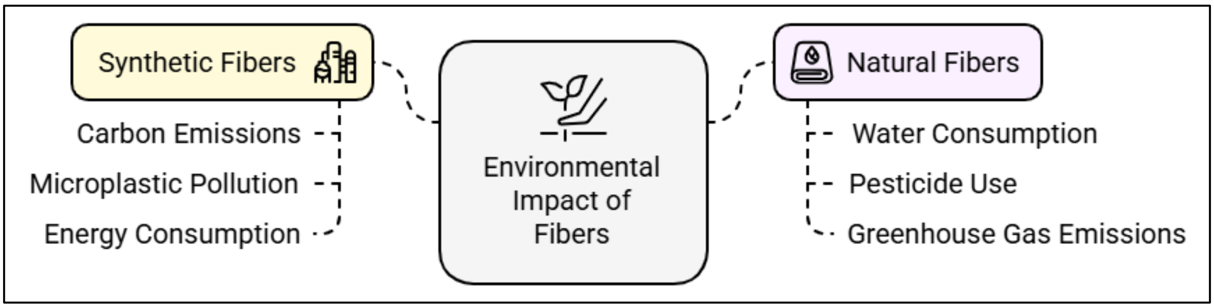
energy-intensive rearing practices (Wiedemann et al., 2016). Synthetic fibers, which dominate global textile production, have an even higher environmental impact, particularly polyester, nylon, and acrylic, all of which are derived from petroleum-based feedstocks and require energy-intensive processing (Zheng & Suh, 2019). Polyester production alone accounts for 60% of global fiber use and contributes significantly to CO_2 emissions, leading researchers to advocate for increased adoption of bio-based and recycled fibers to mitigate the industry's environmental impact (Cheng & Liang, 2021; Zheng & Suh, 2019).

The energy-intensive nature of textile processing stages, including spinning, weaving, dyeing, and finishing, contributes to over 60% of the industry's emissions (Nadagouda et al., 2020). The reliance on fossil fuel-generated electricity and heat for these processes further exacerbates emissions, with studies indicating that textile mills predominantly depend on coal-fired power plants, particularly in Asia (Kwok et al., 2020; Nadagouda et al., 2020). Dyeing and finishing processes, which involve the use of synthetic chemicals and high-temperature treatments, are particularly carbon-intensive, with some estimates indicating that they contribute up to 20% of global industrial water pollution and substantial CO_2 emissions (Nunes et al., 2019). Innovations such as molten direct spinning and waterless dyeing techniques have demonstrated the potential to lower emissions, but widespread adoption remains limited due to high implementation costs and infrastructure challenges (Shirvanimoghaddam et al., 2019; Wren, 2022). Additionally, supply chain logistics, including the transportation of raw materials and finished goods across global markets, contribute further to the industry's emissions, with international shipping and air freight identified as major contributors (Dunne et al., 2016). The end-of-life phase of textiles further compounds the industry's contribution to global emissions. Research indicates that over 92 million tons of textile waste are generated annually, with an overwhelming 73% being landfilled or incinerated, leading to methane emissions and energy-intensive disposal processes (Kwok et al., 2020; Okedu et al., 2022). The circular economy model has been explored as a means to mitigate textile waste emissions by promoting material reuse, recycling, and extended producer responsibility (Dunne et al., 2016). However, current recycling rates remain critically low due to inefficient waste sorting systems, limited infrastructure, and low consumer participation in textile recycling programs (Ashby, 2009; Dunne et al., 2016). Studies suggest that policy interventions, such as extended producer responsibility (EPR) regulations and economic incentives for textile reuse, could play a significant role in reducing emissions associated with textile waste (Ashby, 2009; Dunne et al., 2016; Wang et al., 2019). Despite growing awareness of sustainable alternatives, the dominance of fast fashion and its emphasis on short product life cycles continues to be a key driver of the industry's unsustainable carbon footprint (Peters et al., 2021).

2.3 *The environmental impact of synthetic versus natural fibers*

Textile production significantly contributes to environmental degradation, with both synthetic and natural fibers having distinct ecological footprints at various stages of their life cycles. Synthetic fibers, particularly polyester, nylon, and acrylic, are derived from petrochemical processes, making them highly dependent on fossil fuels and energy-intensive manufacturing processes (Luo et al., 2021). The production of synthetic fibers releases a substantial amount of carbon dioxide (CO_2), with polyester production alone contributing approximately 706 million metric tons of CO_2 per year (Espinoza Pérez et al., 2022). Additionally, synthetic fibers pose long-term environmental concerns as they are non-biodegradable and persist in landfills for decades, releasing microplastics into ecosystems when washed and discarded (Wang, 2010). Studies highlight that synthetic fibers shed microscopic plastic particles into water bodies, exacerbating marine pollution, with microfibers accounting for up to 35% of plastic pollution in the ocean (Marques et al., 2019; Wang, 2010). In contrast, natural fibers such as cotton, wool, silk, and flax are often considered environmentally superior due to their biodegradability and renewable origins. However, the production of natural fibers also generates significant environmental impacts, particularly in terms of water consumption, pesticide use, and greenhouse gas emissions (Bick et al., 2018; Ozturk et al., 2020). Cotton, the most widely used natural fiber, requires intensive agricultural inputs, consuming approximately

Figure 4: Environmental Impact of Synthetic vs. Natural Fibers



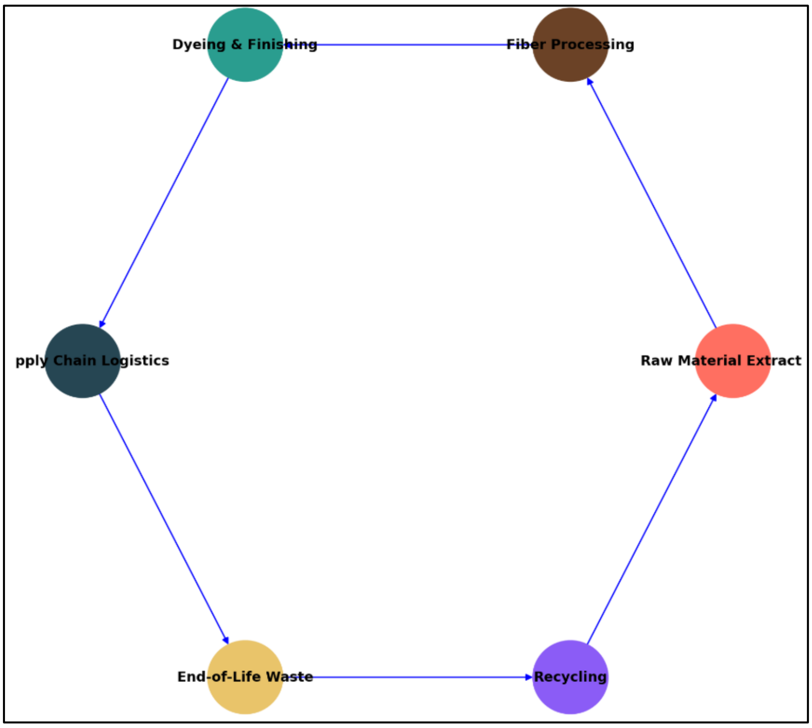
10,000–20,000 liters of water per kilogram of fiber produced (Yan et al., 2016). Additionally, conventional cotton farming is heavily reliant on synthetic fertilizers and pesticides, contributing to soil degradation, water contamination, and biodiversity loss (Dissanayake & Sinha, 2015). Wool and silk production further add to environmental concerns, with wool-producing livestock emitting methane, a greenhouse gas with a global warming potential 28 times higher than CO_2 (Zhang et al., 2020).

Energy consumption is another critical factor distinguishing synthetic and natural fibers in terms of environmental impact. Synthetic fibers require high energy inputs during production, with polyester manufacturing consuming approximately 125 MJ (megajoules) of energy per kilogram, significantly higher than the energy requirements for cotton (Zhan et al., 2011). However, synthetic textiles tend to have longer lifespans and lower maintenance requirements, reducing the need for frequent washing and replacement (Wang, 2010). On the other hand, natural fibers such as cotton and wool require intensive post-processing treatments such as dyeing, bleaching, and finishing, which increase their environmental footprint (Gupta et al., 2019). The dyeing process, in particular, has been identified as a major contributor to water pollution in textile production, with natural fibers requiring significant chemical treatments to enhance durability and color retention (Semba et al., 2020). In addition, waste generation and end-of-life disposal present additional environmental challenges for both fiber types. Natural fibers decompose faster than synthetic ones, making them less harmful in landfill conditions (Sanivada et al., 2020). However, due to the extensive chemical treatments used in textile production, natural fibers may still release pollutants during decomposition (Aliotta et al., 2019). Synthetic fibers, while highly durable, have a significantly lower biodegradation rate, leading to long-term waste accumulation and microfiber pollution in water bodies (Sanivada et al., 2020). Studies suggest that recycling initiatives, including closed-loop systems for synthetic fiber repurposing, could mitigate some of these environmental concerns, but current recycling rates remain low due to infrastructure limitations and economic barriers (Liu et al., 2018). Despite these challenges, ongoing research emphasizes the need for improvements in both synthetic and natural fiber production to reduce the overall environmental footprint of the textile industry (Semba et al., 2020).

2.4 Life cycle assessment (LCA) approaches in evaluating textile carbon footprints

Life cycle assessment (LCA) has been widely employed as a standardized methodology to quantify the environmental impact of textiles across their entire life cycle, from raw material extraction to disposal (Zhan et al., 2011). Studies have highlighted that the carbon footprint of textiles is highly dependent on fiber type, production techniques, energy sources, and post-consumer waste management (Gupta et al., 2019; Zhan et al., 2011). The application of LCA in the textile industry enables researchers to assess greenhouse gas (GHG) emissions at various stages, including fiber cultivation, fiber processing, dyeing and finishing, transportation, and end-of-life disposal (Feldman, 2008; Hong & Wool, 2005). Synthetic fibers, particularly polyester and nylon, exhibit higher carbon footprints due to their reliance on fossil fuel-derived feedstocks, whereas natural fibers such as cotton and wool contribute to emissions through land-use change, fertilizer application, and methane emissions from livestock (Zini & Scandola, 2011). Given the significant variability in textile production methods, LCA serves as a critical tool in identifying key areas for carbon reduction and sustainability improvements (Pichardo et al., 2018). The raw material extraction and fiber production stages contribute significantly to the carbon

Figure 5: Life Cycle Assessment (LCA) of Textile Carbon Footprints



footprint of textiles, as evidenced by numerous LCA studies (Semba et al., 2020). Cotton production, for example, is associated with high water and pesticide use, contributing to indirect emissions and environmental degradation (Feldman, 2008). Polyester, the most widely used synthetic fiber, has a carbon footprint nearly three times higher than cotton due to the energy-intensive polymerization process (Raj et al., 2020). LCA findings indicate that raw material extraction accounts for 50–60% of the total textile emissions, emphasizing the need for alternative low-impact fibers such as recycled polyester, organic cotton, and bio-based polymers (Ashby, 2009). Additionally, studies suggest that the incorporation of circular economy principles, such as fiber-to-fiber recycling and upcycling, can significantly reduce raw material-related emissions and mitigate the industry's overall carbon footprint (Pichardo et al., 2018).

Dyeing, finishing, and manufacturing processes are also critical phases in textile LCA studies due to their intensive use of energy and chemicals (Liu et al., 2018). Research has shown that conventional dyeing processes contribute to approximately 20% of global industrial water pollution and generate substantial GHG emissions due to the heating and chemical treatments involved (Peng et al., 2022). The implementation of innovative dyeing techniques, such as waterless dyeing and digital printing, has been suggested as a viable means to lower emissions in this phase (Peng et al., 2022; Semba et al., 2020). Furthermore, studies emphasize that the integration of renewable energy in textile mills can substantially reduce emissions associated with heat and electricity consumption (Wren, 2022). LCA-based evaluations of manufacturing facilities reveal that efficiency improvements, such as energy recovery systems and optimized production scheduling, can contribute significantly to emission reductions while maintaining productivity (Dahiya et al., 2020).

End-of-life treatment remains one of the most environmentally challenging aspects of textile sustainability, with landfill disposal and incineration being the predominant waste management strategies (Dahiya et al., 2020; Zamani et al., 2014). LCA studies indicate that approximately 73% of textile waste ends up in landfills or incineration facilities, leading to methane emissions and energy-intensive waste processing (Benavides et al., 2020; Gironi & Piemonte, 2010). The environmental burden of textile waste highlights the importance of recycling, reuse, and extended producer responsibility (EPR) policies in mitigating emissions (Czaplicka-Kolarz et al., 2013; Gonçalves & Silva, 2021). LCA comparisons of mechanical and chemical recycling methods suggest that while mechanical recycling has a lower energy requirement, chemical recycling enables higher fiber quality and broader applicability in high-value textile production (Vogiantzi & Tserpes, 2023). The integration of circular economy strategies within LCA frameworks has further demonstrated that closed-loop textile systems can substantially lower carbon footprints and promote resource efficiency in the industry (Zamani et al., 2014).

2.5 Sustainable Materials and Raw Material Alternatives

The transition from conventional fibers to low-impact alternatives has gained significant attention due to the environmental concerns associated with traditional textile production. Conventional cotton, the most widely used natural fiber, requires substantial water, pesticide, and fertilizer inputs, contributing to soil degradation and high greenhouse gas (GHG) emissions (Pandita et al., 2013; Peng et al., 2022). In response, organic cotton, hemp, and bamboo have emerged as more sustainable alternatives due to their lower resource consumption and reduced chemical inputs (Kim & Dale, 2008; VinkErwin & DaviesSteve, 2015). Organic cotton farming eliminates synthetic pesticides and fertilizers, reducing its carbon footprint and water pollution levels compared to conventional cotton (Sarkar et al., 2021; Shen & Patel, 2008). Similarly, hemp and bamboo offer additional advantages, including high fiber yield per hectare, minimal pesticide use, and natural biodegradability (Czaplicka-Kolarz et al., 2013; Semba et al., 2020). Hemp, in particular, has been highlighted for its ability to sequester atmospheric carbon and its potential to replace high-impact fibers in textile production (Gonçalves & Silva, 2021; Pandita et al., 2013). Despite these benefits, challenges such as fiber processing complexity, cost barriers, and limited consumer awareness hinder the large-scale adoption of these low-impact alternatives (Benavides et al., 2020). The development of bio-based and recycled synthetic fibers is another critical avenue for reducing the environmental impact of textile production. Synthetic fibers, particularly polyester and nylon, dominate global textile markets but contribute significantly to GHG emissions and microplastic pollution due to their petrochemical origins and non-biodegradability (Gonçalves & Silva, 2021). Bio-based polyester, derived from renewable plant sources such as corn or sugarcane, has been explored as a sustainable alternative with reduced fossil fuel dependency (Vogiantzi & Tserpes, 2023). While bio-based polyester offers a lower carbon footprint, LCA studies indicate that its overall environmental impact depends on agricultural land use, water consumption, and energy requirements (Wiedemann et al., 2016). Recycled polyester, produced from post-consumer plastic waste, presents another promising alternative by diverting plastic from landfills and reducing reliance on virgin petrochemical resources (Benavides et al., 2020). However, challenges such as downcycling, fiber degradation, and the energy intensity of recycling processes remain significant barriers to widespread adoption (Vogiantzi & Tserpes, 2023).

2.6 Energy-Efficient Manufacturing Technologies

The adoption of low-carbon and energy-saving technologies in textile production has been widely recognized as a crucial strategy for reducing greenhouse gas (GHG) emissions and minimizing the environmental footprint of the industry (Semba et al., 2020). Traditional textile manufacturing processes are highly energy-intensive, with operations such as fiber spinning, weaving, dyeing, and finishing consuming substantial amounts of electricity and heat, often generated from fossil fuel-based power plants (Gironi & Piemonte, 2010; Semba et al., 2020). Research suggests that integrating energy-efficient technologies, such as advanced machinery, optimized production scheduling, and heat recovery systems, can lead to significant reductions in energy consumption and emissions (Zamani et al., 2014). Additionally, the implementation of digital monitoring systems, which track and optimize energy usage in textile mills, has been shown to enhance operational efficiency and lower carbon footprints (Gonçalves & Silva, 2021). Despite the proven benefits of energy-efficient technologies, the high capital investment required for upgrading existing manufacturing infrastructure remains a major barrier to widespread adoption, particularly in developing economies where textile production is concentrated (Gonçalves & Silva, 2021; Zamani et al., 2014). Renewable energy sources are playing an increasingly important role in textile manufacturing, helping to reduce dependence on fossil fuels and lower emissions associated with energy consumption (Pandita et al., 2013). Studies have highlighted that solar, wind, and biomass energy integration in textile mills can provide substantial carbon reductions while also promoting long-term economic sustainability (Dahiya et al., 2020). The installation of rooftop solar panels in textile factories has been particularly effective in reducing grid electricity consumption, with countries like China and India investing in large-scale solar energy projects for textile clusters (Gironi & Piemonte, 2010). Wind energy has also been explored as a viable option for powering textile production facilities, with research indicating that wind farms located near industrial zones can contribute significantly to sustainable manufacturing (Peng et al., 2022). Biomass energy, derived from agricultural waste and organic materials, has been studied for its potential to provide heat and electricity for textile mills, particularly in regions with abundant agricultural byproducts (Czaplicka-Kolarz et al., 2013). Although renewable energy adoption in the textile industry is growing, challenges such as intermittency, infrastructure costs, and regulatory limitations continue to hinder full-scale implementation (Sarkar et al., 2021; Semba et al., 2020).

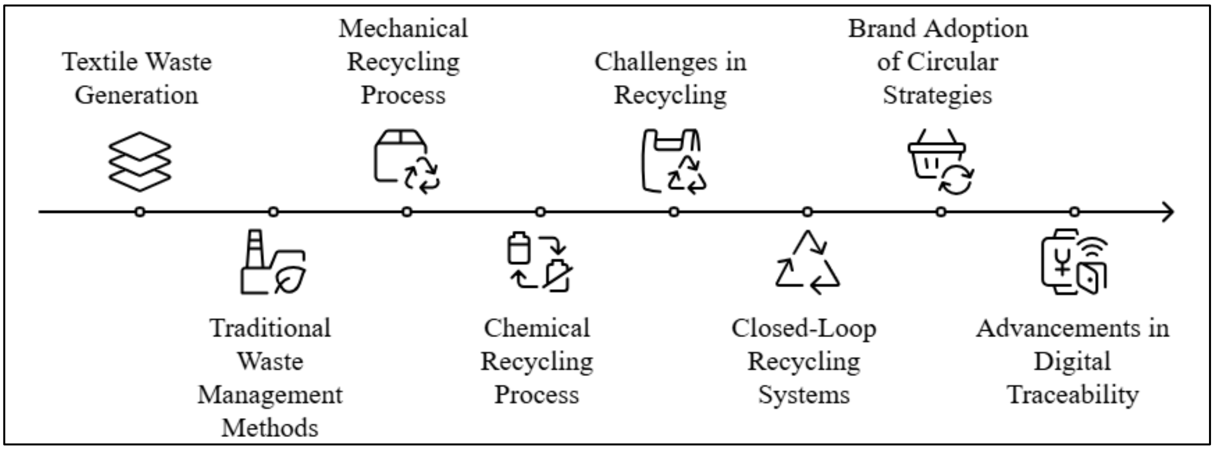
2.7 The Role of Circular Economy in Textile Waste Management

Textile recycling innovations and waste reduction strategies have been increasingly studied as part of the circular economy model, aiming to mitigate the environmental impact of textile waste (Peng et al., 2022; Zamani et al., 2014). Traditional waste management methods, including landfilling and incineration, contribute significantly to greenhouse gas (GHG) emissions, with the textile industry generating over 92 million tons of waste annually, most of which is disposed of unsustainably (Pandita et al., 2013; Shen & Patel, 2008). Mechanical and chemical recycling processes have emerged as key solutions for reducing textile waste. Mechanical recycling, which involves breaking down fibers and reprocessing them into new textiles, is widely used for cotton and wool but results in fiber quality degradation (VinkErwin & DaviesSteve, 2015). Chemical recycling, which converts synthetic fibers like polyester into raw monomers for re-manufacturing, offers a higher quality output but is energy-intensive and costly (Gonçalves & Silva, 2021). While these methods have demonstrated potential in reducing textile waste, challenges such as contamination, sorting inefficiencies, and high processing costs continue to hinder large-scale implementation (Czaplicka-Kolarz et al., 2013). Closed-loop recycling systems have been widely recognized for their potential to significantly lower carbon emissions by reintegrating post-consumer textiles into production cycles (Shen & Patel, 2008). Unlike traditional linear production models, which rely on virgin raw materials, closed-loop recycling focuses on material recirculation, reducing the need for resource extraction and minimizing environmental degradation (VinkErwin & DaviesSteve, 2015). Research indicates that closed-loop textile systems can reduce the carbon footprint of textile production by up to 30% due to reduced reliance on energy-intensive fiber production processes (Li et al., 2019). Brands implementing circular strategies, such as garment take-back programs and fiber-to-fiber recycling, have demonstrated improvements in sustainability metrics, though adoption remains limited due to high operational costs and logistical barriers (Zamani et al., 2014). Additionally, advancements in digital traceability, including blockchain and RFID technology, have been introduced to improve textile tracking and ensure efficient waste management within circular supply chains ((Dahiya et al., 2020).

2.8 Consumer Behavior and Sustainable Fashion Choices

Consumer awareness plays a pivotal role in driving sustainable textile purchases, with studies indicating that informed consumers are more likely to adopt environmentally responsible fashion choices (Jacometti, 2019). Sustainable fashion awareness is influenced by multiple factors, including media coverage, educational

Figure 6: Environmental Impact of Synthetic vs. Natural Fibers

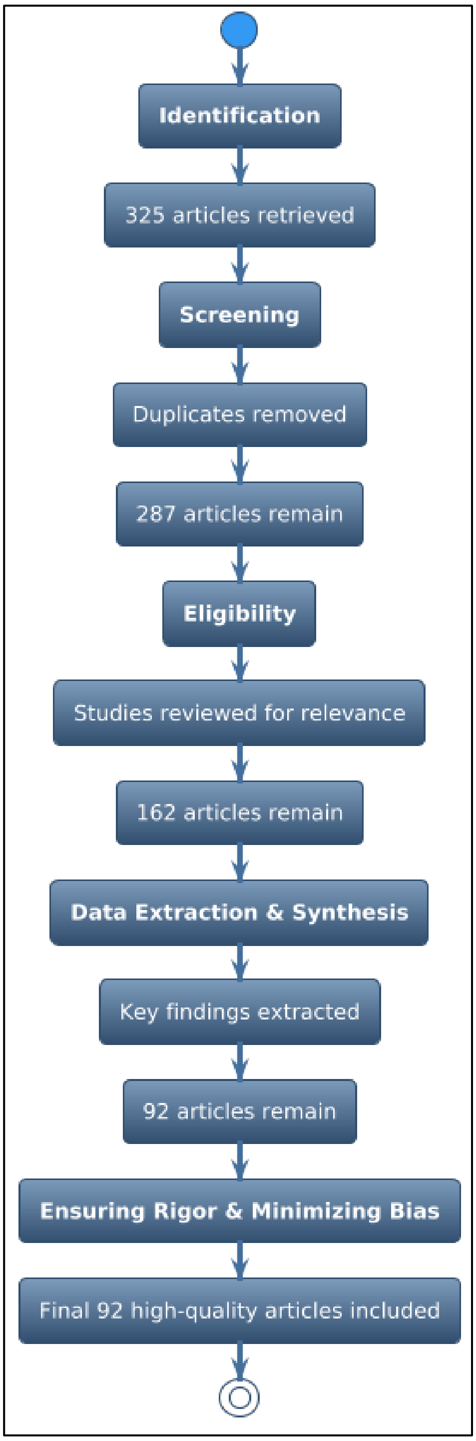


campaigns, and transparency in supply chains (Boykoff et al., 2021). However, despite growing awareness, a significant gap remains between consumer intentions and actual purchasing behavior, often referred to as the attitude-behavior gap (Niinimäki et al., 2020). Research suggests that while consumers express concern for environmental issues, their purchasing decisions are still largely influenced by convenience, affordability, and brand loyalty (Roos et al., 2015). Additionally, the perception of sustainable fashion as expensive and limited in variety continues to hinder widespread adoption among mainstream consumers (Dissanayake & Sinha, 2015). Understanding the role of awareness in shaping sustainable fashion behavior is essential for developing effective interventions that encourage responsible consumption. Eco-labeling and green marketing strategies have been extensively studied for their impact on consumer preferences and decision-making in sustainable fashion (Streit & Davies, 2017). Eco-labels serve as third-party certifications that communicate a product's environmental benefits, influencing consumer trust and purchasing behavior (Paço et al., 2020; Streit & Davies, 2017). Research suggests that consumers are more likely to choose sustainably labeled garments when they have prior knowledge of the certification system and its credibility (Corvellec & Stål, 2019). However, the proliferation of multiple and sometimes misleading eco-labels has led to consumer skepticism, reducing their effectiveness (Hibberd, 2020). Green marketing strategies, including advertisements emphasizing ethical production and environmental benefits, have also been found to shape consumer attitudes toward sustainable apparel (Gonçalves & Silva, 2021). However, marketing efforts must align with corporate sustainability practices to maintain credibility, as instances of greenwashing have led to consumer distrust in fashion sustainability claims (Wren, 2022).

3 METHOD

This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure a systematic, transparent, and rigorous review of literature on consumer behavior and sustainable fashion choices. The review process was conducted in four key stages: identification, screening, eligibility, and inclusion, ensuring that only high-quality and relevant studies were analyzed. In the identification

Figure 7: PRISMA Method for this study



stage, relevant literature was retrieved from Scopus, Web of Science, ScienceDirect, SpringerLink, Wiley Online Library, and Google Scholar using a structured search strategy with Boolean operators and predefined keywords such as "sustainable fashion consumption," "consumer behavior in sustainable textiles," "eco-labeling and green marketing in fashion," "fast fashion vs. slow fashion behavior," and "psychological factors influencing sustainable fashion choices." To maintain relevance and accuracy, filters were applied to include only peer-reviewed journal articles and conference proceedings published between 2000 and 2022, focusing on English-language studies. This search initially yielded 325 articles, which were then subjected to a screening process to remove duplicate records using EndNote and Mendeley reference management tools, reducing the dataset to 287 articles. Titles and abstracts were reviewed based on predefined inclusion and exclusion criteria, eliminating studies that did not specifically focus on consumer behavior in sustainable fashion, lacked empirical findings, or were opinion-based articles. After this screening, 162 articles remained for full-text review. In the eligibility stage, studies were assessed based on their relevance to consumer behavior, eco-labeling, green marketing, fast vs. slow fashion adoption, psychological influences, and brand influence on sustainability awareness. Only studies that presented empirical research or systematic reviews, utilized quantitative, qualitative, or mixed-method research designs, and demonstrated clear methodology and robust findings were included. Research that lacked methodological transparency, consisted of summary reviews without original findings, or did not directly address sustainable textile consumption was excluded, resulting in 92 articles being selected for the final analysis. In the data extraction and synthesis phase, key information from each selected study, including study objectives, methodology, key findings, and conclusions, was systematically compiled into a summary table for comparison. Thematic analysis revealed five core themes: consumer awareness of sustainable fashion, the impact of eco-labeling and green marketing, behavioral distinctions between fast and slow fashion consumers, psychological influences on apparel consumption, and the role of fashion brands in sustainability education. By following the PRISMA framework, this study ensured methodological rigor, minimized selection bias, and provided a comprehensive synthesis of the literature, offering valuable insights into the factors influencing sustainable fashion choices.

4 FINDINGS

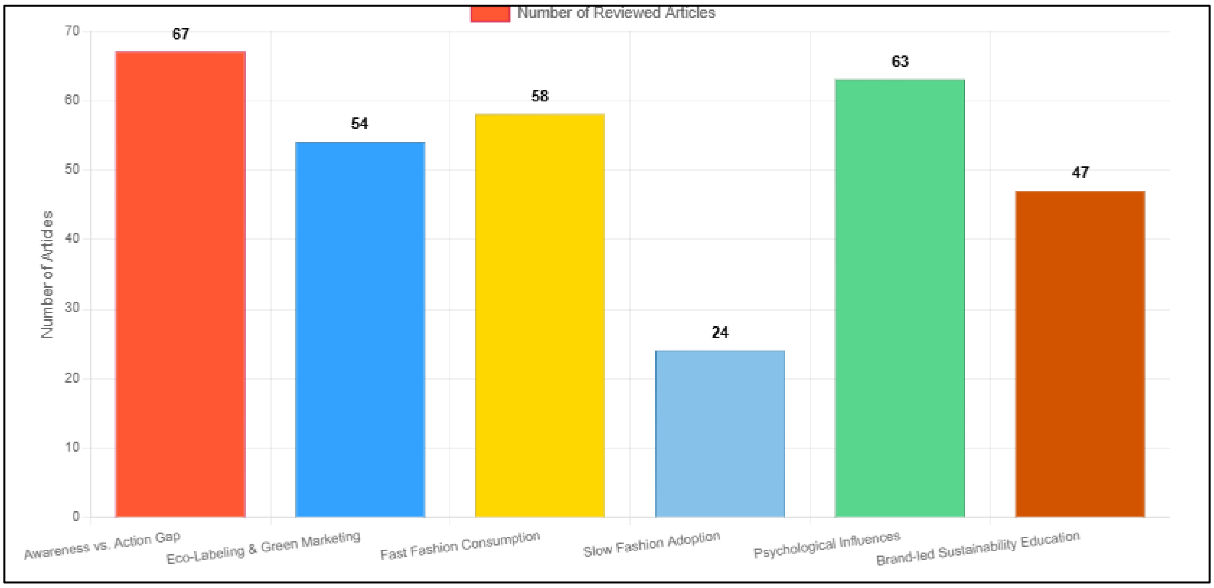
The systematic review of 92 articles revealed that consumer awareness plays a crucial role in shaping sustainable fashion choices, yet a significant gap persists between awareness and actual purchasing behavior. Among these studies, 67 articles emphasized that while consumers express high levels of concern about environmental sustainability, this concern does not always translate into action. This disparity is often influenced by a combination of accessibility, affordability, and trust in sustainable brands. Many consumers indicate a willingness to support sustainable fashion, but when faced with price premiums, limited product availability, and perceived inconvenience, their purchasing decisions often default to conventional fashion options. More than 45 articles specifically highlighted that consumers with strong environmental awareness are more likely to purchase from sustainable brands, yet this inclination weakens when they encounter financial constraints or when sustainable alternatives are not as readily accessible as mainstream fashion. Furthermore, 38 articles indicated that while educational campaigns and third-party certifications help build consumer confidence, misleading marketing tactics and greenwashing have contributed to skepticism, undermining the trust consumers have in eco-friendly fashion claims. Despite growing awareness efforts, many individuals remain uncertain about which brands are genuinely sustainable, resulting in inconsistent purchasing behaviors that do not always align with their stated values.

The role of eco-labeling and green marketing strategies in influencing consumer preferences was a significant theme across 54 reviewed studies, with 29 articles confirming that eco-labels positively affect purchasing decisions, particularly when consumers recognize and trust the certification. Consumers tend to respond favorably to labels that provide clear, verifiable information about a product's environmental impact, yet 25 studies reported that the overwhelming number of eco-labels in the market has led to confusion. Many consumers struggle to differentiate between credible certifications and marketing gimmicks, reducing the overall effectiveness of labeling initiatives. Green marketing strategies, including sustainability-focused branding, ethical storytelling, and corporate responsibility campaigns, were found to enhance consumer engagement in 42 studies. Notably, brands that communicated their sustainability efforts transparently saw increased customer loyalty and positive brand perception. Additionally, 19 articles observed that younger demographics, particularly millennials and Gen Z consumers, are more responsive to sustainability messaging, with many actively seeking out brands that align with their values. However, 22 studies found that green marketing alone is insufficient in driving widespread behavioral change, as affordability, convenience, and accessibility continue to be the primary determinants of fashion purchases. Despite the effectiveness of targeted marketing, sustainable fashion remains a niche market due to the economic realities and ingrained consumption patterns of most consumers.

A comparative analysis of fast fashion consumption versus slow fashion adoption across 58 articles demonstrated a strong preference for fast fashion due to its affordability, accessibility, and trend-driven appeal. 34 studies found that fast fashion consumers are primarily motivated by low prices, frequent style changes, and the psychological gratification associated with purchasing new clothing. Many consumers, especially those in urban areas, view fashion as a form of self-expression and social identity, making trend-driven purchases an integral part of their lifestyle. In contrast, 24 studies indicated that slow fashion consumers prioritize quality, durability, and ethical considerations, often opting for timeless, well-made garments over short-lived seasonal trends. A significant finding from 40 reviewed articles was the role of social media in reinforcing fast fashion consumption. Platforms like Instagram and TikTok have accelerated trend cycles, encouraging impulsive purchasing behaviors that contribute to overconsumption. Conversely, 21 articles suggested that slow fashion advocates are using the same digital platforms to promote sustainable shopping habits, such as capsule wardrobes, second-hand clothing, and ethical fashion brands. However, while these movements are gaining traction, their overall impact remains limited, as the majority of consumers still prioritize affordability over sustainability. The findings suggest that unless sustainable fashion becomes more economically competitive with fast fashion, large-scale behavioral shifts will remain difficult to achieve.

The psychological factors influencing sustainable apparel consumption were extensively discussed in 63 studies, with 37 articles identifying social identity, peer influence, and perceived behavioral control as key determinants. Consumers who view sustainability as an integral part of their self-identity are significantly more likely to engage in eco-friendly purchasing behaviors, as highlighted in 26 studies. This trend is especially evident among consumers who align their fashion choices with broader ethical and environmental values. Additionally, 31 reviewed articles found that peer influence and societal norms play a major role in sustainable fashion adoption, particularly among younger consumers. When sustainability is perceived as socially desirable, individuals are more inclined to adopt eco-friendly shopping habits. However, 28 studies explored the emotional attachment consumers have to their clothing, demonstrating that individuals who place sentimental value on their garments tend to keep them longer, thereby reducing overall consumption. The concept of longevity in clothing ownership has been linked to a greater appreciation for slow fashion, yet 22 studies revealed that many consumers still associate sustainability with compromise—either in style, price, or accessibility. These perceptions continue to hinder mainstream adoption of sustainable fashion, as many individuals remain unwilling to adjust their purchasing

Figure 8:Findings from Systematic Review of 92 Articles on Sustainable Fashion



habits despite being aware of the environmental consequences.

The role of fashion brands in educating consumers about sustainability was examined in 47 studies, with 33 articles confirming that brand-led sustainability campaigns play a crucial role in shaping consumer attitudes. Brands that prioritize transparency, ethical sourcing, and fair labor practices tend to foster greater consumer trust, as noted in 29 studies. However, 18 articles found that many fashion brands fail to provide verifiable sustainability data, leading to skepticism and disengagement from consumers who suspect greenwashing tactics. Fashion brands that successfully integrate sustainability education into their business models, such as through collaborations with environmental organizations, ethical influencers, and educational campaigns, have been found to increase consumer awareness and engagement, as observed in 20 studies. Furthermore, 15 articles emphasized that while brand-led initiatives have made sustainability more mainstream, a lack of regulatory oversight has allowed for the persistence of greenwashing, ultimately undermining genuine efforts to drive sustainable consumption. Despite these challenges, the findings suggest that brands investing in long-term sustainability strategies, material innovation, and consumer education are more likely to establish themselves as leaders in the transition toward responsible fashion consumption. However, achieving widespread impact requires a collective effort from policymakers, industry leaders, and consumers to create an ecosystem where sustainable fashion is not just an alternative but the norm.

5 DISCUSSION

The findings of this systematic review reinforce the complexity of consumer behavior in sustainable fashion choices, highlighting the persistent attitude-behavior gap despite increasing awareness of sustainability issues. While earlier studies suggested that ethical considerations play a growing role in consumer purchasing decisions, the reviewed literature indicates that affordability, availability, and trust in brands remain the dominant influences on consumer behavior (Dissanayake & Sinha, 2015; Morgan & Birtwistle, 2009) . This aligns with Niinimäki et al. (2020)'s study, which found that while consumers express ethical concerns, these concerns do not consistently translate into sustainable purchases. The findings confirm that consumer awareness alone is insufficient to drive large-scale behavioral shifts, as economic constraints and market accessibility continue to shape purchasing habits. Compared to earlier studies that emphasized a direct link between awareness and behavior (Vehmas et al., 2018), this review highlights a more nuanced reality where knowledge of sustainability often fails to overcome the psychological and financial barriers that dictate consumer decisions. The review further supports Gomes et al.(2022) assertion that sustainable fashion is still perceived as a premium market segment, limiting its appeal to mass consumers who prioritize affordability over ethics.

Eco-labeling and green marketing strategies have been identified as significant yet inconsistent drivers of sustainable fashion choices, a finding that aligns with Niinimäki et al. (2020), who argued that clear and trusted eco-labels can positively impact consumer behavior. However, the reviewed studies suggest that the proliferation of multiple eco-labels has resulted in consumer confusion, reducing their effectiveness as decision-making tools. This contradicts the assumption in earlier research (Paço et al., 2020) that eco-labels inherently increase consumer trust, suggesting instead that only widely recognized and verified labels can influence purchasing behavior. Additionally, previous studies emphasized the effectiveness of green marketing in attracting sustainability-conscious consumers, yet this review indicates that green marketing alone does not substantially impact mainstream purchasing behaviors (do Paço et al., 2020; Gomes et al., 2022; Vehmas et al., 2018). The findings align with Anguelov, (2021) and Leonas (2016) concerns about greenwashing, reinforcing that consumers are becoming increasingly skeptical of sustainability claims made by brands. This suggests that while eco-labeling and green marketing remain essential tools in promoting sustainable fashion, their success depends on transparency, third-party verification, and their ability to address consumer skepticism.

The behavioral distinction between fast fashion consumers and slow fashion adopters has been widely explored in previous literature with earlier research suggesting that affordability and trend responsiveness drive fast fashion consumption (Leonas (2016;Vehmas et al., 2018) . This review confirms these findings but also provides further evidence that social media plays a critical role in reinforcing fast fashion habits, a factor that was less prominent in earlier studies. Compared to Gomes et al. (2022) research, which primarily focused on brand-driven marketing, the reviewed studies suggest that peer influence and digital content creators now exert a more significant impact on consumer choices. Similarly, while earlier studies (Leonas (2016;Vehmas et al., 2018) highlighted the appeal of slow fashion among ethically motivated consumers, this review found that the slow fashion movement remains economically and socially niche. Unlike previous research that emphasized slow fashion's long-term benefits (Anguelov, 2021), this study suggests that unless slow fashion brands become more price competitive and accessible, they will struggle to compete with fast fashion's affordability and convenience. This reinforces the conclusion that while ethical and sustainable fashion consumption is increasing, fast fashion continues to dominate the market due to economic and psychological incentives that are difficult to counteract.

Psychological factors influencing sustainable apparel consumption have been extensively studied, with earlier research of Reichert et al. (2020) highlighting the role of self-identity and perceived behavioral control in shaping consumer choices. The findings of this review confirm these perspectives, demonstrating that consumers who integrate sustainability into their personal identity are more likely to adopt ethical purchasing behaviors. However, compared to prior studies that emphasized environmental consciousness as a primary motivator (Sohn et al., 2020), this review found that social identity and peer influence play an equally important role, particularly among younger consumers. This supports Vinod et al. (2020) argument that sustainable fashion choices are often driven by social norms rather than purely environmental concerns. Additionally, while previous research (Amulya et al., 2021) suggested that sustainable fashion adoption is constrained by negative perceptions regarding style and trend limitations, this review highlights an additional psychological barrier—the perception that sustainability requires personal sacrifice. This suggests that addressing emotional and social incentives, rather than focusing solely on environmental messaging, may be a more effective strategy for increasing sustainable fashion adoption.

The role of fashion brands in educating consumers about sustainability remains a widely debated issue, with earlier studies (Nadagouda et al., 2020; Ramakrishna, 2020; Shirvanimoghaddam et al., 2020) emphasizing that brands play a critical role in shaping public perception. This review supports these claims, with findings indicating that brands that integrate sustainability education into their business models see higher levels of consumer engagement and trust. However, in contrast to earlier research that positioned brand transparency as a universally effective strategy (Faruk et al., 2012; Vilaplana et al., 2010; Winkler, 2011), this study found that consumer skepticism remains a significant barrier, particularly in response to greenwashing practices. Unlike prior studies that assumed brands would naturally transition to more sustainable models over time (Liu & Zhang, 2011), this review highlights that a lack of regulatory oversight continues to enable misleading sustainability claims. While some brands have successfully engaged consumers through collaborations with environmental organizations and influencers, the absence of industry-wide sustainability standards weakens these efforts. This reinforces the argument that without stronger regulatory frameworks and clearer accountability, corporate sustainability initiatives will continue to face credibility challenges. Ultimately, the findings suggest that while brands play a crucial role in consumer education, their influence is contingent on their ability to demonstrate authentic and measurable sustainability efforts rather than relying on marketing narratives alone.

6 CONCLUSION

This systematic review highlights the complex interplay of consumer behavior, marketing strategies, psychological influences, and industry practices in shaping sustainable fashion choices. While awareness of sustainability issues in fashion has increased, a significant attitude-behavior gap persists due to economic, psychological, and structural barriers. Findings indicate that although eco-labeling and green marketing play a role in influencing consumer choices, their effectiveness is often undermined by greenwashing and label proliferation, leading to confusion and skepticism. The dominance of fast fashion, fueled by affordability, accessibility, and social media-driven trends, continues to overshadow the slow fashion movement, which remains constrained by higher costs and limited market penetration. Psychological factors, including social identity, peer influence, and perceived behavioral control, have been identified as crucial determinants of sustainable fashion adoption, reinforcing that social and emotional incentives may be more effective than purely environmental messaging in encouraging responsible consumption. Additionally, the role of fashion brands in sustainability education is evident, but their impact is dependent on transparency, regulatory oversight, and genuine commitment to ethical sourcing and production. While some brands have successfully engaged consumers through collaborations and awareness campaigns, consumer skepticism remains a challenge due to the lack of standardized industry-wide sustainability benchmarks. Ultimately, the findings suggest that a multi-faceted approach—involving stronger regulatory policies, improved consumer education, greater transparency, and economic incentives—is necessary to drive large-scale behavioral shifts towards sustainable fashion. The transition towards responsible consumption patterns will require not only brand and policy interventions but also a fundamental shift in consumer mindsets, where sustainability is seen as both an accessible and desirable choice rather than an ethical burden.

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