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S.I. : GREENWASHING

A comprehensive review of greenwashing in the textile industry (life cycle assessment, life cycle cost, and eco-labeling)

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Abstract

This study explores the phenomenon of greenwashing, where companies and industries mislead consumers and shareholders by presenting a positive environmental image that is not supported by their actions. The textile industry, known for its significant contribution to environmental pollution, is the focus of this research. The investigation begins by defining greenwashing and discussing its classification, causes, and consequences. They then examine the laws and standards in the textile industry, which aim to reduce pollution and environmental impact. The investigation further delves into specific topics related to the textile industry, such as fast fashion, the circular economy, and sustainability. It delves into the examination of life cycle assessment (LCA) and the utilization of the ReCiPe approach for assessing the ecological footprint of textile materials. The findings reveal that the use phase and manufacturing have the most significant environmental impacts. The study also discusses the Rescorla–Wagner learning algorithm in the context of life cycle cost (LCC) simulation. The simulation results unequivocally illustrate that the implementation of eco-labeling practices across various textile industries can yield remarkable improvements in environmental sustainability, surpassing the 90% mark. Furthermore, the environmental impact assessment underscores that the most significant environmental impacts are primarily concentrated in the usage and manufacturing phases, thus emphasizing the critical importance of enacting strategic policies in these domains.

Keywords Greenwashing · Circular economy · Life cycle assessment · Eco-labeling

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Abbreviations

LCA	Life cycle assessment
LCC	Life cycle cost
SOEs	State-owned enterprises
MNCs	Multinational corporations
CSR	Corporate social responsibility
GOTS	Global Organic Textile Standard
USGBC	United States Green Building Council
LEED	Leadership in energy and environmental design
ESG	Environmental, social, and governance
GRI	Global reporting initiative
SASB	Sustainability Accounting Standards Board
ETFs	ESG-focused exchange-traded funds
TSMC	Taiwan Semiconductor Manufacturing Company

1 Introduction

In recent decades, due to the increasing pollution of the environment, people and companies worldwide have paid more attention to environmental problems. The trend of environmental protection has caused changes in consumer behavior. Consumers are more interested in an environmentally friendly life because they want to be environmentally responsible and benefit from green items (Kim & Lyon, 2015; Marchand & Walker, 2008). The term greenwashing was initially coined by activist Pearson (2010) when hotels encouraged guests to reuse towels, ostensibly for water conservation (Pearson, 2010). Greenwashing involves the dissemination of inaccurate or incomplete information with the intent to project an environmentally responsible public image (Furlow, 2010). It encompasses various deceptive messages aimed at fostering overly positive perceptions of a company's environmental practices (Lyon & Montgomery, 2015). The prevalence of greenwashing has grown significantly (Ruiz-Blanco et al., 2022; Delmas & Burbano, 2011) and is not limited to business entities alone (Kim & Lyon, 2015). As Lyon and Montgomery (2015) note, this practice is conducted by a range of actors, including for-profit organizations, governments, politicians, research institutions, international bodies such as the United Nations and the World Bank, NGOs, and social, and environmental movements. In recent years, instances of greenwashing, where communications mislead individuals into forming unduly positive opinions about an organization's environmental actions or products, have become more prevalent than corporate claims about their ecological performance (Lyon & Montgomery, 2015).

In recognizing greenwashing as a deceptive environmental communication technique, several researchers have attempted to comprehend why and how businesses engage in greenwashing (Chen & Chang, 2013; Du, 2015; Testa et al., 2018). According to Walker and Wan, corporations engage in greenwashing for two primary reasons they are to achieve legitimacy (Berthelot et al., 2003) by institutional (Nowiński & Rialp, 2013) and legitimacy theory (Suchman, 1995) and to express the firm's commitment to sustainability. The textile and apparel industry, a crucial component of human existence, stands as one of the most universally expansive sectors on the planet (Da Silva & Teixeira, 2008; Hansen & Schaltegger, 2013). This global textile industry is valued at approximately $1 trillion, representing 7% of the total global exports and supporting a workforce of roughly 35 million individuals worldwide (Exchange, 2010b). Remarkably, despite its significant role in employment generation, the textile industry ranks as a primary contributor to global pollution (Thiry, 2011).

In the state of fashion 2023 report by McKinsey and Company, it is evident that the fashion industry, including fast fashion, faces increasing scrutiny and regulatory pressure regarding its sustainability claims. This underscores the urgency of addressing greenwashing in the sector.

Recent research by Lu (2022) highlights the impact of consumers' perception of greenwashing on their green purchase intention, emphasizing the need to investigate this issue further. Additionally, Inês' work (2023) provides a framework to help firms develop sustainable strategies and prevent greenwashing along the supply chain, indicating the importance of addressing this problem from a supply chain perspective.

The problem statement of the present research is to examine the prevalence of greenwashing in the fast fashion industry, understand its impact on consumers, and propose strategies to mitigate this deceptive practice. This research seeks to contribute to the ongoing efforts to create a more transparent and genuinely sustainable fashion industry, aligned with global sustainability goals.

The fashion industry in 2023 faces a confluence of challenges, with sustainability, greenwashing, and textile waste taking center stage. Recent surveys have underscored the urgency of these issues, revealing growing concerns among consumers and stakeholders. Sustainability has become a defining criterion for brands seeking to align with evolving consumer values and industry standards. However, this pursuit of sustainability is accompanied by the persistent problem of greenwashing, wherein companies mislead consumers with superficial eco-friendly claims. Recognizing this, regulatory authorities are cracking down on greenwashing practices, introducing stricter requirements to combat misleading information in the fashion sector. Brands are now tasked with navigating this shifting landscape and adopting genuine sustainability practices to maintain consumer trust and compliance with regulatory mandates (Thakker & Sun, 2023).

Textile waste, another formidable challenge, contributes significantly to environmental degradation. The fashion industry's fast-paced production and consumption cycles generate massive amounts of waste, particularly in the form of microfiber shedding. To address this issue effectively, the industry must focus on reducing the environmental impact of microfiber shedding and reevaluating production systems. Resale systems, once seen as a sustainable solution, have also come under scrutiny, with studies suggesting that they do not significantly lower production levels, especially for fast fashion brands. The imperative now lies in implementing holistic approaches that encompass sustainable production, responsible consumer behavior, and a commitment to reducing textile waste. As the fashion industry grapples with these interconnected challenges, it must embrace innovation, transparency, and regulatory compliance to drive lasting positive change (Yousaf & Aqsa, 2023).

The current research items suggest an important connection between the study on greenwashing in the textile industry and the broader context of Industry 4.0, the circular economy, and global value chains. This linkage highlights the need to understand how advancements in Industry 4.0 and the principles of the circular economy can play a pivotal role in addressing the issue of greenwashing within global value chains.

Firstly, in the context of Industry 4.0, technological advancements such as automation, data analytics, and the internet of things (IoT) can be harnessed to track and verify environmental claims made by companies in real-time. By integrating these technologies into supply chains, it becomes easier to monitor the sustainability practices of suppliers and detect instances of greenwashing. This alignment between Industry 4.0 and sustainability efforts can enhance transparency and accountability, which are crucial in combating greenwashing (Majeed & Kim, 2023).

Additionally, the circular economy principles emphasize the importance of resource efficiency and minimizing waste. Linking this concept to the study on greenwashing in the textile industry, it is evident that addressing environmental impacts during the use phase and manufacturing aligns with circular economy goals. Strategies like product life extension, recycling, and reducing waste can be part of a comprehensive approach to mitigate greenwashing and promote genuine sustainability (Ruiz-Blanco et al., 2022).

Furthermore, considering global value chains, the study should explore how companies operating in these complex networks can better align their environmental practices and disclosure standards to prevent greenwashing. Global value chains provide opportunities for sharing best practices and establishing consistent sustainability standards across borders (Johnsson et al., 2020).

Big data enhances supply chain sustainability, countering greenwashing through transparent reporting and risk management. Emphasizing innovative green products not only builds credibility but is crucial for authentic sustainability. In the post-COVID era, prioritizing analytics becomes key for risk reduction. As suggested by Nisar et al. (2022), applying big data analysis in textile industries offers a novel approach to reducing greenwashing. In sustainable supply chain management, implementing smart systems based on big data presents a fresh perspective for controlling corruption in proceedings, as highlighted by Nisar et al. (2022).

Regarding the textile and green clothing industries, more research should be conducted in this area. So, one field that needs to be investigated is the connection between the textile industry and greenwashing. Many studies have been done in the textile industry, but studies have yet to be done on the relationship between this industry and greenwashing. Therefore, in this article, the authors tried to examine the relationship between the textile industry and greenwashing from the point of view of circular economy, sustainability, and life cycle evaluation. In the present study, the greenwashing assessment protocols are simulated in MATLAB 2019b based on life cycle assessment, life cycle cost, and eco-labeling concepts.

The main research question of the present study is: How can the implementation of eco-labeling practices in the textile industry effectively mitigate greenwashing and enhance environmental sustainability, particularly in the context of the LCA and the ReCiPe method?

While there is a growing awareness of greenwashing and its detrimental effects on consumer trust and environmental protection, there is a limited understanding of how eco-labeling practices, specifically in the textile industry, can serve as a viable solution to mitigate this phenomenon. Existing research primarily focuses on identifying instances of greenwashing and its consequences, but there is a gap in exploring concrete strategies and their potential impact on improving environmental sustainability in this industry. Furthermore, the integration of LCA and the ReCiPe method in this context is relatively unexplored, leaving room for investigation into their practical application.

The textile industry is notorious for its significant environmental impact, including high levels of pollution and resource consumption. Greenwashing within this industry not only misleads consumers and stakeholders but also hinders genuine efforts to reduce environmental harm. Therefore, understanding how eco-labeling practices, informed by LCA and the ReCiPe method, can be effectively used to combat greenwashing and enhance sustainability is of paramount importance. This research seeks to provide insights that can influence policymakers, industry patrons, and consumers in making judgments to promote environmental responsibility in the textile sector.

The assumptions of the present study are:

- Eco-labeling practices have the potential to influence consumer choices and encourage textile companies to approve more sustainable performances.
- Utilizing LCA in conjunction with the ReCiPe method offers a holistic insight into the ecological ramifications of textile materials and manufacturing procedures.
- Implementing strategic policies, guided by simulation results, can lead to significant improvements in environmental sustainability within the textile industry.
- The most critical environmental impacts in the textile industry are concentrated in the usage and manufacturing phases, warranting targeted interventions in these areas.

Greenwashing in the textile industry presents a pressing challenge, as companies often misrepresent their environmental efforts, erode consumer trust, and hinder genuine progress towards sustainability. The textile industry's substantial environmental impact underscores the urgency of addressing this issue. To bridge the existing research gap and provide practical solutions, this study aims to investigate how the implementation of eco-labeling practices, supported by LCA and the ReCiPe method, can effectively combat greenwashing and substantially improve environmental sustainability within the textile industry.

2 Literature review

Based on the data shown in Fig. 1a, it is readily apparent that the field of greenwashing within the textile industry has garnered significant research attention. Notably, the majority of these investigations have been conducted in the USA, China, and the UK, signifying the global relevance and interest in addressing environmental issues and deceptive practices in the textile sector.

Figure 1b reinforces the multidisciplinary nature of research on greenwashing in this context. It highlights that a substantial portion of the research endeavors are concentrated in the domains of business and management, comprising approximately 21% of the total research output. Additionally, the social sciences field follows closely behind, representing 20.5% of the research items. Environmental sciences also play a significant role, accounting for 16.2% of the total research output.

This distribution across various disciplines underscores the complexity of the greenwashing phenomenon within the textile industry. It reflects the recognition that addressing this issue necessitates a multifaceted approach, involving not only environmental considerations but also business strategies, consumer behavior, and regulatory aspects. The involvement of social sciences highlights the importance of understanding how consumers perceive and respond to greenwashing claims.

Overall, the insights drawn from Fig. 1a, b suggest a concerted effort by researchers worldwide to comprehensively tackle the challenges posed by greenwashing in textile industries, while also acknowledging the interdisciplinary nature of this research area.

Adamkiewicz et al. (2022) provides valuable insights into the risks and gains related to greenwashing practices in the fashion industry, shedding light on the challenges faced by companies attempting to present a positive environmental image while addressing the need for genuine sustainability. Salomone (2023) offers an in-depth examination of fast fashion's

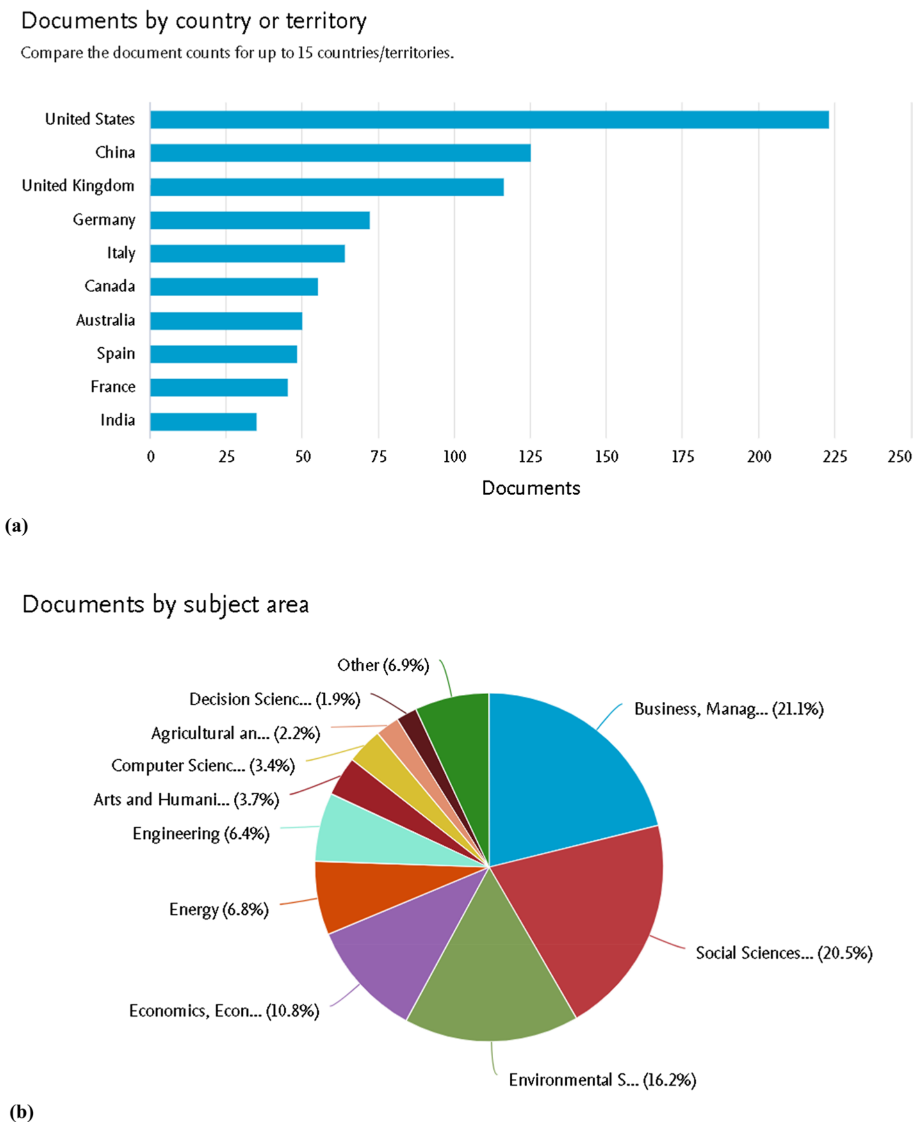


Fig. 1 The diagrams of **a** research and **b** based on Scopus databank

association with greenwashing and its adverse effects on sustainability. This study contributes to a better understanding of the challenges faced by the fashion industry in achieving true sustainability. Yildirim (2023) explores the two sides of greenwashing and its implications for sustainability. This study utilizes descriptive evidence to provide a comprehensive view of greenwashing in literature. Plakantonaki et al. (2023) offers an extensive review of sustainability standards and eco-labeling in the textile and apparel industry. It highlights the importance of accurate eco-labeling practices to combat greenwashing. Tonti (2022) discusses the crackdown on greenwashing across the fashion industry and the efforts of regulators worldwide to address misleading sustainability claims.

These studies collectively emphasize the challenges posed by greenwashing in the textile industry and the critical need for transparency, genuine sustainability efforts, and effective policies to combat this deceptive practice. They underscore the importance of accurate environmental assessments and eco-labeling practices to promote sustainability in the fabric sector.

The application of life cycle assessment (LCA) in the textile industry has gained substantial attention as a powerful tool for evaluating the ecological influences of textile products during their intact life cycle (Baydar et al., 2015). LCA plays a pivotal role in pinpointing areas for potential enhancements to lessen environmental impacts, rendering it a valuable resource in the textile industry's pursuit of sustainability. However, this industry is not without its challenges, one of which is the pervasive issue of greenwashing, where companies make deceptive environmental claims about their products (Roy et al., 2014). To combat greenwashing effectively, robust LCA methodologies and transparent eco-labeling practices are crucial. A comprehensive understanding of these dynamics is essential to ensure that consumers are provided with accurate information regarding the environmental performance of textile products, fostering informed choices and genuine progress toward sustainability in the textile industry (Goffetti et al., 2022).

The textile industry has witnessed a surge in the application of eco-labeling practices as a means to communicate the items' environmental qualities to customers. Eco-labels serve as valuable tools for promoting transparency and sustainability within industry. However, this positive trend also brings with it the challenge of greenwashing, where companies misrepresent their products as environmentally friendly. To combat greenwashing effectively, robust eco-labeling standards and certifications are crucial, ensuring that the claims made on product labels align with verifiable environmental practices. The incorporation of eco-labeling not only empowers consumers to make informed choices but also incentivizes textile companies to adopt genuinely sustainable practices, thus advancing the industry's environmental performance (Dahl, 2010; Drozdowski, 2023).

The present effort focuses on the critical issue of greenwashing within the fast fashion industry, a topic of growing concern in recent years. Greenwashing refers to the deceptive practice where companies claim to be environmentally friendly while failing to implement genuine sustainable practices.

This study delves into greenwashing in the textile industry, exploring its definition, causes, and consequences. It scrutinizes industry laws, focusing on topics like fast fashion and sustainability. Through life cycle assessment, the study identifies manufacturing and usage as major environmental impacts. The Rescorla-Wagner algorithm in life cycle cost simulation advocates for eco-labeling, showing over 90% improvement. Environmental impact assessment emphasizes the need for strategic policies. Overall, the research offers a thorough analysis and suggests practical strategies, especially eco-labeling, to enhance sustainability in the textile sector.

3 Methodology

This study deals with the relationship between greenwashing and the textile industry and is based on content analysis.

According to Randolph (2009), a reliable and systematic review requires collecting information that begins with electronic research of academic databases and the internet, so the authors chose scientific databases such as Google Scholar, Research Gate, and Scopus for reference. Moreover, in the next step, keywords were selected using articles to continue the search, which saves research time and finds related articles. The authors combined the keywords of greenwashing, textile industry, fast fashion, and circular economy with the keywords of sustainability and life cycle assessment and green production and the relationship between the textile industry and greenwashing with these items; as a result of this research, many articles were selected, then among these again, a limited number of articles and journals were selected for evaluation according to the abstract, keywords, and the main topic of the article and journal. In addition, in the end, the authors categorized the articles based on whether they were research, review, or book. Also, to distinguish the articles by the review method, the impact factor was used.

Moreover, they paid attention to their citations. Then these selected sources were examined to obtain valuable information about the connection between the textile industry and greenwashing. Also, this relationship is reviewed from different perspectives, such as circular economy, fashion industry, sustainability, and life cycle assessment.

The methodology of this section aims to simulate greenwashing in the textile manufacturing by appraising the environmental impacts of textile materials and detecting potential deceptive claims. To achieve this, a MATLAB program is developed. The simulation utilizes an LCA methodology, specifically focusing on the ReCiPe technique, to measure the environmental effects across all stages of the product's life cycle, encompassing activities such as raw material extraction, processing, production, utilization, and disposal. Key variables representing CO2eq emissions for each stage are introduced with a 30% random deviation to account for system variability. The simulation spans one-year with monthly calculations, and total environmental impacts for each month are determined by summing the impacts across all life cycle stages, providing valuable insights into potential greenwashing practices in the textile industry (Amini et al., 2021; Gheibi et al., 2018). The stages of the programming in the present section are shown as per Fig. 2.

In the present study ChatGPT tool is used for some modifications in programming and grammar suggestions and modifications of some sections of research which are checked by authors.

The methodology employed for the computation of LCC in this program is focused on assessing the financial aspects of an outcome or system over its complete cycle. This computational model, developed using MATLAB, involves several key steps. To begin with, the software establishes the pertinent cost classifications and their corresponding subcategories, including capital expenditures, operational expenses, upkeep costs, and disposal expenditures. It then collects and organizes data for each cost category, including cost estimates and time frames for different life cycle phases. Next, the program performs financial calculations, such as discounting future costs to their present values using an appropriate discount rate. It also considers inflation and escalation factors to ensure the accuracy of cost estimates over time. The program accounts for uncertainties and variations in cost data by incorporating sensitivity analyses and Monte Carlo simulations. Additionally, it provides the option to perform scenario analyses to explore different cost scenarios and make informed decisions. Ultimately, the program generates comprehensive reports and visualizations to present the LCC results, facilitating effective decision-making in evaluating the economic viability of products or systems throughout their life cycles (Liu et al., 2023). The schematic plan of the LCC calculations in the present practice is shown in Fig. 3.

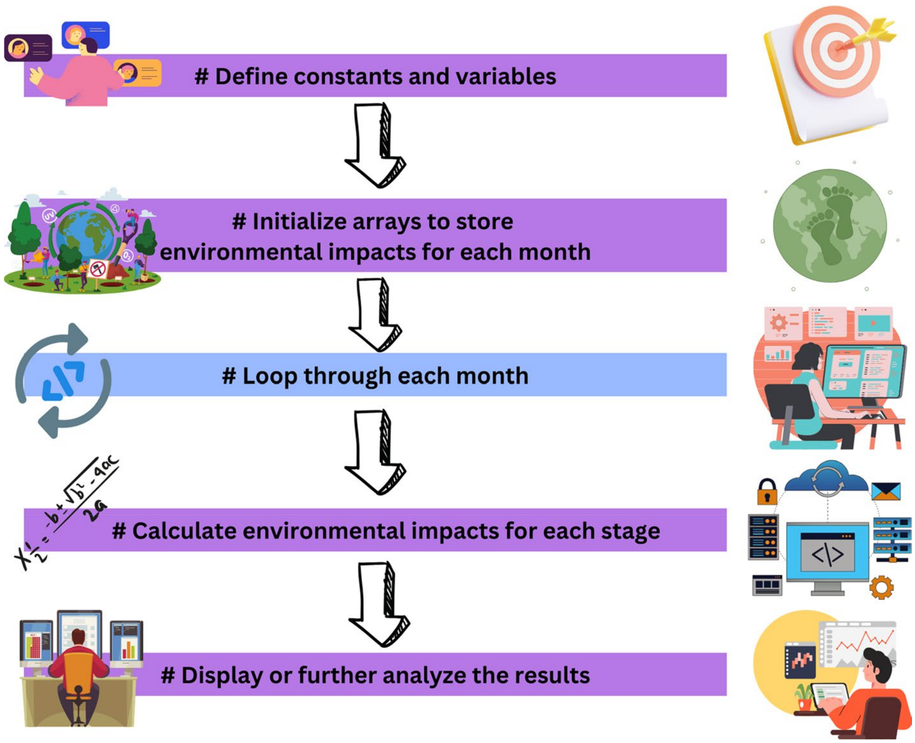


Fig. 2 The schematic plan of LCA assessment in the present study

The presented methodology, implemented using MATLAB 2019b, aims to compute eco-label scores for textile products based on their environmental attributes, specifically focusing on CO2 emissions and water consumption. The approach involves aggregating environmental data for each stage of a product's life cycle across multiple manufacturing plants, constructing a 12-month time series matrix with a 20% random variability factor to represent the product's environmental impact. Eco-label scores are then determined monthly for each plant, guided by predefined criteria. If CO2 emissions fall within the CO2_threshold and water consumption is below the water threshold, a top score of five is assigned; meeting either criterion results in a partial score of 2.5, while failing to meet both yields a score of 0. This method ensures standardized and transparent communication of textile product environmental impacts, mitigating greenwashing by delivering reliable information to consumers for informed decision-making. The study concludes by generating 3D visualizations of eco-label scores, offering a holistic view of the environmental performance of these textile products across diverse companies (Asif et al., 2023). The diagram in Fig. 4 shows the conceptual framework for implementing eco-labeling as a programming strategy to combat greenwashing.

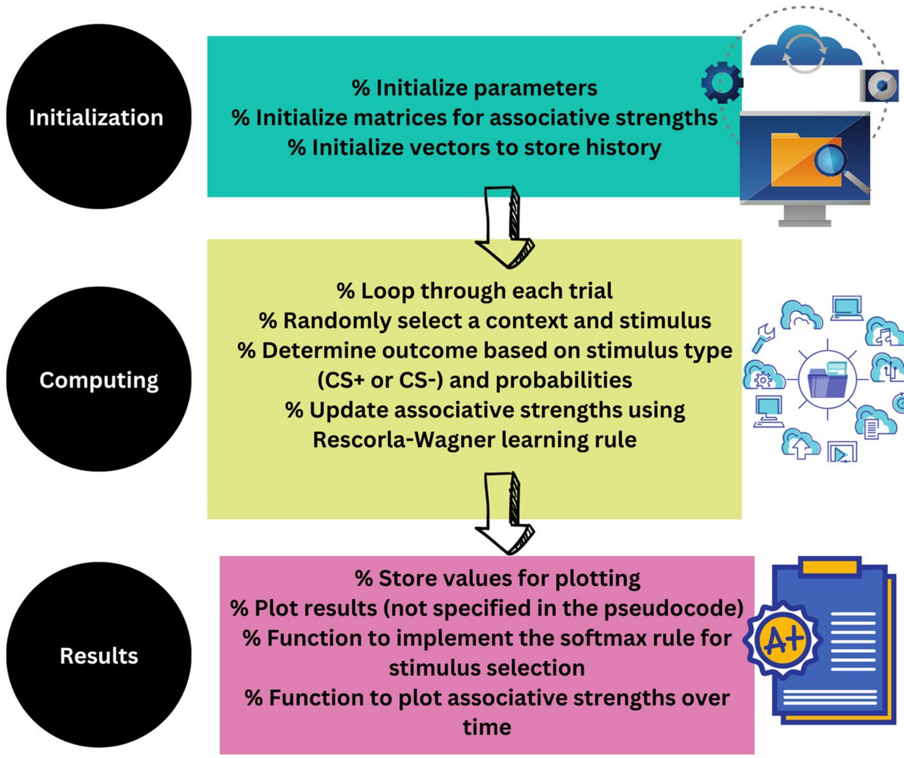


Fig. 3 The methodology of LCC computations in the present investigation

4 Results and discussion

4.1 Greenwashing

Greenwashing was invented by environmentalist Pearson (2010) after observing a hotel requesting visitors to reuse towels to “benefit the environment” while the hotel did not want to wash guests’ towels to save money. The word was then applied to “outrageous corporate environmental claims.” (Romero, 2008).

4.1.1 Some main definitions of greenwashing

- “Presenting positive narratives regarding a company’s environmental or financial performance while withholding negative information in these areas to create a favorable commercial scheme.” (Lyon & Maxwell, 2011).
- “Insufficient environmental performance paired with effective environmental communications” (Delmas & Burbano, 2011).
- “The act of misleading customers regarding a company’s environmental policies or the environmental benefits of a product or service” (Parguel et al., 2011).

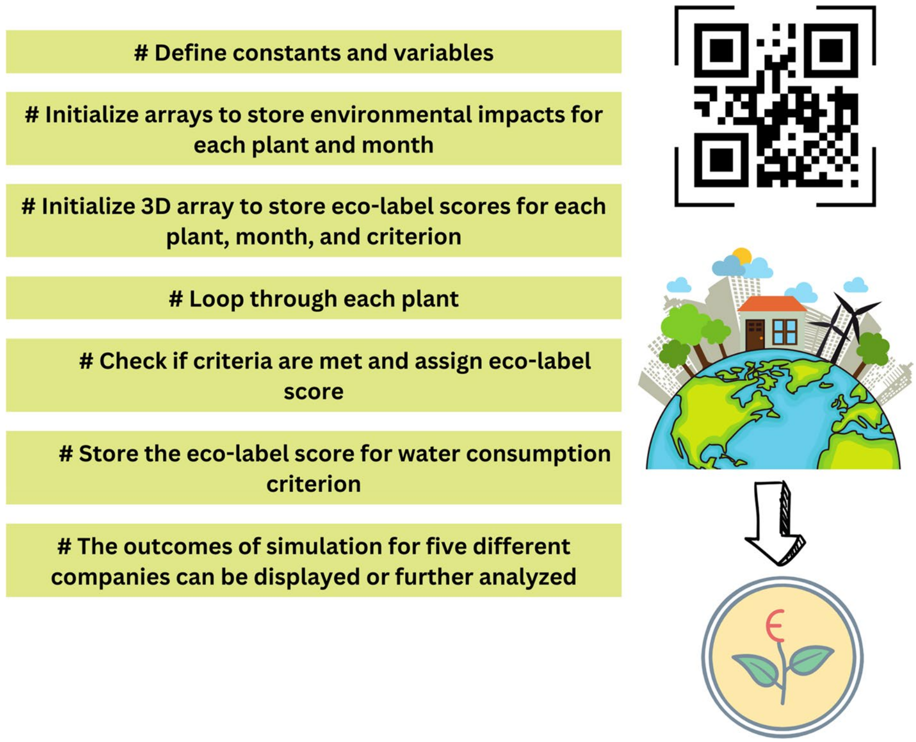


Fig. 4 The attitude of eco-labeling programming in the research

- "A distinct category within corporate environmentalism that features intentionally symbolic and purely symbolic changes" (Bowen & Aragon-Correa, 2014).
- "Symbolic data is generated inside an administration, but no respectable programs are taken." (Walker & Wan, 2012).

4.2 The classification of greenwashing

Apart from the four typically acknowledged forms of greenwashing (firm-level claim, firm-level executional, product-level claim, and product-level executional), an alternative categorization distinguishes greenwashing into six distinct groups. These six categories encompass selective disclosure, decoupling, attention deflection, deceptive manipulation, questionable authorizations and labels, and ineffective public voluntary programs which is shown in Fig. 5 (Falcão et al., 2020).

4.3 Reasons for greenwashing

State-owned enterprises (SOEs), multinational corporations (MNCs), and private businesses are all examples that operate in emerging markets. MNCs play a critical role as partners in investing in finance and technology transfer. Despite continuing policies with detrimental or unexpected repercussions, MNCs have had a disproportionately favorable impact on emerging markets. MNCs positively affect host markets, including rising living

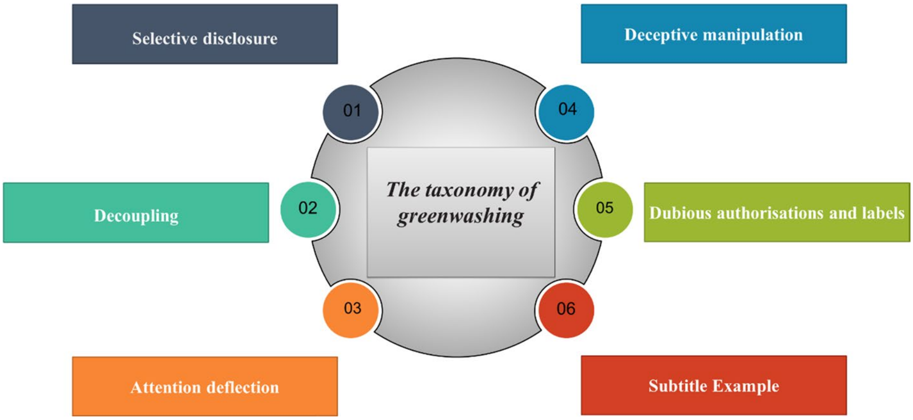


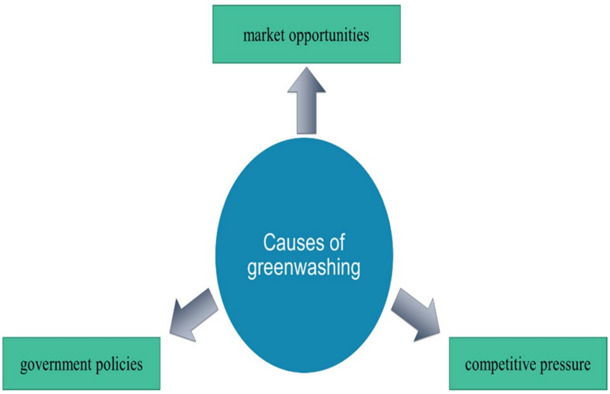
Fig. 5 Green washing classification (Falcão et al., 2020)

standards by improving product quality, lowering prices, and expanding the span of products available. Figure 6 shows other reasons for greenwashing are government policies, competitive pressure, and market opportunities (Yang et al., 2020).

4.4 Outcomes of greenwashing

Corporate social responsibility (CSR) has the potential to enhance a firm's appeal to identifiable investors, leading to favorable customer attitudes and procurement objectives (Jamali & Karam, 2018). In its broadest context, CSR represents an effort to achieve business success while upholding ethical principles and demonstrating respect for people, communities, and the natural environment. Figure 7 summarizes the outcomes of greenwashing (Bhattacharya & Sen, 2004). However, corporate greenwashing, primarily practiced by multinational corporations, has detrimental effects on consumers and possible participants. The impact on sponsors is more complicated, as it involves two categories: available and probable sponsors. Greenwashing can benefit available stakeholders by increasing financial gains (Solomon & Edgley, 2008). Conversely, greenwashing harms society, as indicated by the negative externality in welfare economics. The second category comprises committed

Fig. 6 Reasons of greenwashing (Yang et al., 2020)



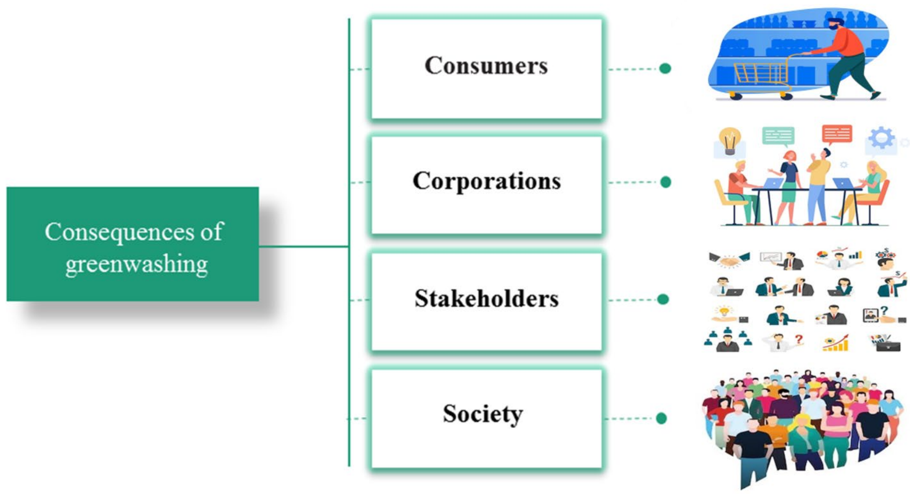


Fig. 7 Consequences of greenwashing (Guo et al., 2018)

potential stakeholders, such as investors, who seek to engage with companies producing genuinely environmentally friendly products and engaging in CSR initiatives. Greenwashing makes it challenging for prospective investors to support companies producing genuinely environmentally beneficial products. Green brands and their stakeholders may suffer substantial damage to brand trust due to greenwashing (Guo et al., 2018). Failure to prevent greenwashing in a timely manner can have long-term consequences, dissuading entrepreneurs and stakeholders from participating in the creation of environmentally friendly products for the market and incentivizing corporations to engage in harmful practices. Greenwashing generates negative externalities, ultimately harming social well-being. In the subsequent analysis, the repercussions of greenwashing are explored from the perspectives of customers, shareholders, organizations, and society.

Many companies employ corporate social responsibility (CSR) communication as a means to enhance their corporate image, one of several ethical corporate marketing strategies. Nonetheless, consumers often find themselves perplexed by these well-intentioned CSR declarations, which can make it challenging to distinguish responsible businesses (Parguel et al., 2011).

4.4.1 Customers

The deceptive tactics employed by a single brand engaging in greenwashing can have a detrimental impact on consumers' willingness to purchase eco-friendly products from other companies within the same industry (Wang et al., 2019). To begin with, greenwashing inundates consumers with a barrage of information, making it increasingly difficult for them to effectively assess products (Gosselt et al., 2019; Walsh et al., 2007). Furthermore, when consumers notice a disconnect between a company's actual performance and its environmental claims, they may become skeptical (Nyilasy et al., 2014). Such skepticism can lead consumers to form a negative perception of the hidden motives of a company (Cliath, 2007). Consequently, people are becoming increasingly skeptical of businesses that capitalize on the environmental movement (Nguyen et al., 2019; Pomering & Johnson, 2009). Nyilasy et al. (2014) have contended that greenwashing constitutes an ethical concern. Consumers are becoming increasingly aware of greenwashing, and this significantly impacts brand perception, the capital of green branding, and purchase motivation (Akturan, 2018; Nguyen et al., 2019). As a multitude of environmental claims are vague and misleading, consumers begin to question the sincerity of businesses and accuse them of greenwashing. The issue with greenwashing lies in its capacity to deceive consumers, while businesses genuinely committed to their environmental mission risk losing their competitiveness if dishonest marketers continue to make false claims about being environmentally responsible. Moreover, the misuse and overuse of “green” assertions can saturate the market, rendering the notion of product eco-friendliness meaningless to consumers (Zimmer et al., 1994).

4.4.2 Corporations

Greenwashing is often advantageous for corporations. Some businesses employ greenwashing tactics in order to nurture a perception of environmental friendliness and a positive reputation, spurred by pressures from both shareholders and environmental advocates. Nevertheless, greenwashing can distort the relationship between corporate performance and environmental assessments, thereby affecting the connection between corporate social responsibility (CSR) performance and CSR reporting (Uyar et al., 2020). As a result, these deceptive practices may undermine employees’ trust in their organization due to unsubstantiated claims, leaving them feeling disconnected from their roles (Walker & Wan, 2012). They can also lead to a decline in trust among customers, nongovernmental organizations, and investor groups (Lyon & Montgomery, 2015; Painter-Morland, 2006). Greenwashing contributes to credibility issues and can lead to a reduction in brand equity (Guo et al., 2017). It serves as an obstacle to the advancement of green marketing strategies and has a detrimental impact on the image of environmentally conscious brands and customer satisfaction (Chen et al., 2016).

4.4.3 Stakeholders

Maintaining commitments to stakeholders and meeting their expectations has become a widely adopted approach in marketing and corporate communication strategies (Delmas & Burbano, 2011; Guo et al., 2018; Seele & Gatti, 2017). Initially, greenwashing is a tactic employed to distort a company’s genuine social performance in the eyes of its stakeholders. This method may secure stakeholder support, but it does so with a limited investment in corporate social responsibility (Husted & Allen, 2009). Often, stakeholders lack sufficient information to evaluate the environmental impact of different companies (Busch & Hoffmann, 2009; Lyon & Maxwell, 2011; Pizzetti et al., 2021). Secondly, businesses and the public rely on marketing, but greenwashing erodes their trust. Other businesses may lose faith in a company practicing greenwashing (King & Lenox, 2000), diminishing their willingness to engage in collaborations and resource sharing. They may fear being associated with greenwashing companies, leading them to distance themselves from such entities. Consequently, greenwashing undermines investor confidence and results in unfavorable market reactions. Finally, when a company’s information about its social, governance, and environmental practices lacks credibility, its greenwashing behavior can obstruct the incorporation of environmental, social, and governance considerations into investment decisions (Yu et al., 2020). The repercussions of greenwashing on relationships with these stakeholders ultimately lead to a decline in financial performance, negatively impacting investment (Pizzetti et al., 2021).

4.4.4 Society

Trust in a company's environmental impact can be damaged through greenwashing (Hsu, 2011). According to research, being exposed to greenwashing might raise consumer skepticism and distrust (Chen et al., 2019; Jahdi & Acikdilli, 2009; Nguyen et al., 2019). In most situations, greenwashing negatively impacts customer benefits while enhancing shareholder interest. Even if the advantages to shareholders exceed the losses to consumers, the advantages to society can be diminished, as demonstrated by the allocation of resources and social welfare (Ramesh & Rai, 2017). Therefore, in order to reduce the negative effects of greenwashing on society, it is necessary for the government to make interventions (Sun & Zhang, 2019; Yu et al., 2020).

4.5 Rules and standards in the garment industry

The global organic textile standard (GOTS) is a nonprofit organization that classifies cotton and hemp as organic fibers. The organization, founded in 2006, has garnered worldwide prominence and is regarded as a dependable quality assurance idea by both consumers and businesses (Mikkonen, 2016; Seitenwerkstatt, 2022).

The fibers must meet the GOTS standards listed below to acquire this accreditation: Agriculture is sustainable and conserved. It improves soil fertility while avoiding the use of long-lasting, harmful pesticides and fertilizers. In the textile and clothing manufacturing supply chain, there must be environmental and labor conditions regulations, as well as acceptable animal husbandry and the avoidance of genetic modification. Due to its global partners, GOTS has become an internationally recognized standard (USA, Japan, Germany, and the UK). Being authenticated by a prestigious body would take the business apart from competitors and allow it to justify charging a premium price. The accreditation is not cheap; it might cost up to 4000€ per season for a midsized brand. The cost is also determined by the number of styles certified, putting a financial restriction on the size of a company's collection per season for smaller businesses (Standard, 2008). Fletcher (2013) emphasizes organic production's significant social dimensions and ethical production standards. It is an instrument for social reform as well as agricultural instruction. It is, however, intended to assist struggling smaller family farmers in competing with large commercial farms by giving them a bonus for their produce (Fletcher, 2013).

To regulate the tracking and certification of organic fibers, in 2007, the textile exchange launched the OCS (Organic et al.; previously, OE 100 and Blended Standards). The standard initially designed for organic cotton was amended in 2013 to include all organic fibers. Textile exchange is a nonprofit company with significant ties to the fashion industry. However, its standards are reviewed and critiqued by specialists in the certification industry before they can be published to ensure the best quality and avoid prejudice. They have a long list of credible producers (Mikkonen, 2016). The standard, which is complementary to GOTS, tracks the movement of organic fibers throughout the whole textile supply chain. Even if a textile product does not meet the GOTS requirement of 70% organic fibers, OCS allows a matching organic 'fiber claim.' Due to some overlap between the two standards, with more significant compliance requirements, the OCS can serve as a steppingstone to GOTS. Some varieties of clothes are best certified through OCS since certain types of clothing cannot meet GOTS requirements because of their composition, dyestuff, or trimmings. OCS has the bug of not having the same level of customer recognition as GOTS, which makes it more challenging for small and medium-sized firms to justify. For firms that do not want to overhaul their entire supply chain, OCS is a realistic choice because its standardization procedure is more straightforward than GOTS. Ecocert's guide to OCS certification is strongly recommended for information on the application and certification procedure (Mikkonen, 2016).

4.5.1 Standards for the manufacturing process

Yarn is made from fiber, which will then be weaved or knit to fabric. It is then colored, all of which are treated with finishing treatments before being cut and sewn into clothes and consume varying amounts of energy, water, and chemicals. Figure 8 shows a summary of this process.

The carbon footprint of an activity is determined by how these activities are operated and how their waste is managed; however, some practices can be preferred above others. Fletcher (2013) suggests the following industry standards: utilizing automated methods for metering and dispensing chemicals and managing machine parameters to enhance efficiency; implementing water- and energy-efficiency measurements; avoiding clothes colored with toxic dyes and additives and replacing them with biodegradable or biodegradable (Fletcher, 2013).

4.6 Green production in the textile industry

Two stages have opened up opportunities for the transformation of the textile industry into an environmentally friendly sector. A comparison between the costs of producing garments in the conventional textile industry and the green textile industry suggests that the latter enjoys lower production expenses due to its lower output (Rostami et al., 2017). Consequently, green technology and the adoption of a circular economy approach are the most effective methods for achieving sustainable and environmentally friendly textiles.

The drive to make factories more ecologically sustainable or eco-friendly is gaining global significance as our planet becomes increasingly hazardous for its inhabitants. Each year, millions of people worldwide succumb to health issues caused by poor environmental conditions. A recent report from the World Health Organization reveals that environmental

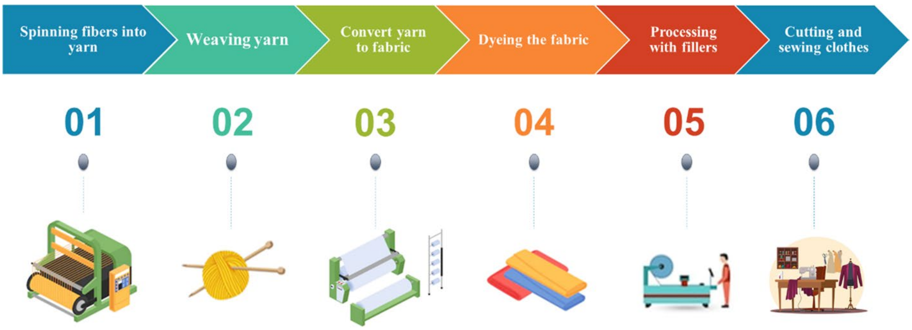


Fig. 8 The linear process of producing clothing from fibers (Fletcher, 2013)

hazards now contribute to over 100 of the most severe global diseases and injuries, resulting in 12.6 million deaths annually, accounting for nearly one in four, or 23% of all fatalities. Given this dire situation, there is a pressing need for environmentally friendly industries. Some organizations, such as the United States Green Building Council (USGBC), have introduced a certification process known as Leadership in Energy and Environmental Design (LEED) to assess a building's environmental performance and promote the shift toward sustainable design (Pieczyńska et al., 2017). As a consequence, 39 factories have been forced to close due to their lack of environmentally friendly features, posing an urgent threat to workers. Therefore, specific criteria must be met to transition the conventional textile industry into a green textile sector (Phifer, 2016).

4.6.1 Use of green fibers for environmentally friendly textiles

Certain fibrous plants have recently been found to be rich sources of phytoestrogens, showing promise in natural medicine. Today, an increasing number of fashion and clothing manufacturers are transitioning to green textiles. The rationale behind this shift is the belief that every stage of textile production can be carried out without the use of pollutants. Textiles can, in fact, reduce their environmental impact from agriculture through manufacturing and distribution.

The term "green technology" is used here to describe the initial phase of developing eco-friendly textiles. "Green technology" encompasses a continually evolving array of methods and materials, ranging from energy generation techniques to the use of nontoxic cleaning products (Rostami et al., 2017). Green fibers can be derived from various plants, resulting in high-quality textile products produced using cutting-edge technology. Sustainable textile manufacturing is a pressing concern, as it takes a substantial 2700 L of water to produce a single t-shirt. This poses a significant challenge to the environment and natural water sources, especially given the substantial water requirements of textile dyeing facilities.

During the dyeing process, textile companies generate substantial effluent containing dyes, sodium sulfate, sodium chloride, sodium hydroxide, and traces of other salts. After the dyeing and washing of garments, large quantities of contaminated water are discharged into the environment. Post-dyeing, wastewater contains around 4–5 percent solid particles, whereas wash water contains only 0.5–1 percent. It is crucial to introduce technology capable of managing such effluent and converting it into reusable water. This approach enables the textile industry to reuse the same water in the dyeing process and recycle or sell the salt utilized in dyeing. Through its production processes and greening of the industry, green technology has led to the creation of environmentally beneficial products (Aktar, 2014).

4.6.2 Production of fiber

In 2019, the amount of fiber produced worldwide was 111 million metric tons, doubling in the prior two decades (Shirvanimoghaddam et al., 2020). Pre-COVID-19 data predicts a likely spread to 146 million metric tons by 2030. (Shirvanimoghaddam et al., 2020; Worley, 2020). Natural and synthetic fibers are the two primary fibers used in apparel. Natural fibers include cotton, silk, wool, and other natural fibers. Synthetic fibers contain nylon, acrylic, polyester, and other synthetic fibers. Synthetic fibers presently account for 69 percent of fiber output. The remainder is made up of natural fibers and blends of synthetic fibers. Synthetic fibers are expected to make up approximately 98% of all future fibers, with polyester accounting for 95 percent (Qin, 2014). The growth of synthetics is a source of environmental worry for various reasons.

These reasons are:

1. The production of synthetic polymers, which can be used directly as colors, fibers, and coatings, is expected to require 98 million tons per year, rendering it reliant on the generation of fossil fuels (Morlet et al., 2017).
2. Synthetic fibers do not break down naturally. They may be able to survive in the ecosystem for a lengthy period.
3. Fibers are also much more hazardous than centimeter-scale polymers due to their smaller size (micron size). Synthetic fabrics, for instance, leak nano- and microfibers into rivers when they are washed, harming ecosystems and marine life in ways that are hard to track 1 if the trend.

4.7 Fast fashion in the textile industry

Fast fashion, as defined by Sundbotten (2021), involves the creation of inexpensive clothing rapidly in response to the latest trends. This strategy minimizes the buying cycle and lead times for fashion trends by frequently updating products (Barnes & Lea-Greenwood, 2010). With the fashion industry's carbon footprint on the rise and fast fashion's emphasis on mass production, there is a pressing need for research on green consumerism. Consumers increasingly seek a balance between affordability and sustainability, with limited trust in unsubstantiated claims of environmental friendliness (De Jong et al., 2018, 2020; Nyilasy et al., 2014). This indicates a reluctance to support greenwashing brands. However, initial data on green claims suggests that consumers often believe a company cares about the environment before uncovering the true nature of its operations. As a result, companies can continue to profit if consumers remain unaware or credible third parties, such as Greenpeace or the European Commission, do not expose their deceptive practices. According to a 2018 Nielsen survey, 81% of people worldwide believe that companies must contribute to environmental progress. The fast fashion industry, as per the United Nations Environmental Program's 2018 research, is responsible for 10% of global carbon emissions and 20% of global wastewater. This environmental impact surpasses that of international flights and marine transport combined, drawing widespread criticism from consumers and environmental activists. Nonetheless, consumers continue to purchase new clothing at an alarming rate, with a 36% reduction in the number of times clothing is worn over the past 15 years (MacArthur, 2017). Gleim et al. (2013) investigated the obstacles to green consumption and found that price was a factor in 42% of cases, indicating consumer hesitation to pay higher prices for environmentally friendly products. This prompts businesses to focus on less green, lower-cost alternatives. Research by TerraChoice indicated a 77% increase in the number of "green" products within a year, but 95% of these products employed greenwashing tactics (2010).

Chen et al. (2014) explored the impact of greenwashing on green word-of-mouth among Taiwanese consumers, identifying three detrimental effects. Firstly, it directly harms consumers' green word-of-mouth. Second, it indirectly affects consumers by diminishing perceived quality. Lastly, it negatively impacts consumer satisfaction with green products, thereby harming green word-of-mouth. This study highlights the overall negative impact of greenwashing in a post-purchase context and underscores the need for further research on green marketing and greenwashing. The demand for low-cost alternatives is growing as people buy more clothes but use them less. Many consumers emphasize the importance of green products and declare that they will not support or purchase from companies that engage in greenwashing or do not positively impact the environment. On average, consumers purchase 60% more clothing each year (Remy et al., 2016) while continuing to support large corporations known for their deliberate greenwashing. Fast fashion is one of the most environmentally harmful industries globally, employing over 26.5 million people (Jönsson et al., 2013). Fashion companies now produce twice as much clothing as they did in the 1990s, with annual growth of 2% (Niinimäki et al., 2020). The fast fashion industry is projected to reach $38.21 billion by 2023 (ResearchAndMarkets.com, ALEXA et al., 2021).

4.8 The textile industry's circular economy

Textiles, especially clothing, play a crucial role in people's lives. However, the alarming rate at which textiles are discarded (equivalent to a garbage truck every second) poses a significant environmental threat if this trend continues. Authorities and responsible organizations are now beginning to call for a redesign of the textile distribution network, transitioning from a linear to a circular model (Chen et al., 2021). In the last two decades, clothing consumption has experienced a remarkable 400% increase (Jia et al., 2020; Shirvanimoghaddam et al., 2020). This surge in consumption has significant implications for the energy required in manufacturing, the quantity of chemicals used in transportation, and the material handling processes during use, all of which seem to have detrimental ecological consequences (Chae & Hinestroza, 2020; Sadeghi et al., 2021). Textile manufacturing, ranking second in greenhouse gas emissions after the oil industry, is the world's second-most polluting sector, accountable for around 1.2 billion tons of emissions (more than the total emissions from international flights and maritime cargo combined) (Change, 2018). It is estimated that by 2050, the fashion industry will consume up to a quarter of the world's carbon budget (Pandey, 2018). To mitigate the negative impacts of the fashion industry on long-term sustainability, it's imperative to adopt the principles of a circular economy (Saha et al., 2021).

Currently, the clothing system operates primarily in a linear fashion, encompassing clothing production, distribution, and usage. Approximately 68% of current fibers are derived from finite fossil fuel resources to create clothing that is manufactured using environmentally harmful processes, worn briefly, and then discarded or incinerated. Annually, approximately $183 million worth of clothing ends up in landfills. This linear system not only squanders significant economic opportunities but also pollutes and harms the environment, depletes valuable resources, and strains societal finances. To effectively address these challenges, a transition from a linear economy to a circular economy is imperative (Gardetti, 2019). The circular economy operates on three fundamental principles and strategies: reduce, reuse, and recycle, all of which are established waste management approaches (Manickam & Duraisamy, 2019). Waste reduction encompasses all stages of production, involving the efficient use of primary resources, as well as all levels of consumption and utilization.

In this scenario, the concept of reuse involves a reevaluation of the production process to create products that can be easily reprocessed or repurposed, ultimately reducing the necessity for new manufacturing. The circular economy brings about clear economic advantages, and it is anticipated that the global economy will expand. If the fashion industry continues to grow at its current pace, it is projected to reach a value of $192 billion by 2030, mitigating the issues associated with the existing linear economic model (Morlet et al., 2017). Employing sustainable resources, reimagining production methods, maximizing product reuse, replication, and recycling, exploring new markets, and extending the lifespan of products are all key actions that contribute to the principles of the circular economy (Kumar & Saravanan, 2019).

4.8.1 Clothing that has been recycled

Nearly 98 percent of final apparel is made of fibers. Only 12% of garment fibers are recycled, and 73% of fibers used in clothes end up in landfills or incinerators (Morlet et al., 2017). Because fibers were few and thus subjected to such rigorous recycling processes that their quality decreases, just 1% of recovered fibers can be reused in clothes, the majority of recycled fibers can only be used for other purposes, including mattress stuffing, cleaning carpets, clothes, and other similar tasks, which is difficult owing to the loss of quality (Notman, 2020). To achieve the best efficiency and sustainability, new fibers can simply be combined with previously recovered fibers. When synthetic fibers, like polyester, are melt-spun, they may be chemically split into their component parts to produce new fibers with the same properties as the virgin fibers entering the circular loop.

This technique has two major drawbacks:

(1) Sorting; and (2) economics. Recycling chemical fibers has proven to be costly, because clothing is often made of mixtures, sorting can be challenging, resulting in fibers that are significantly more expensive than fresh virgin fiber. Such as synthetic fibers with variable qualities that are difficult to separate into individual fibers. Blending in textiles may occur at the yarn and fiber levels, to mention a few. These various layers give fresh suggestions for sorting before recycling to the recycling department.

Overall, stating that clothes are simple to recycle must be more concise. Clothes are notoriously difficult to recycle (Beall, 2020). In this regard, scientists, environmentalists, textile technologists, chemists, and legislators must creatively consider various viable solutions to the recycling issues.

4.9 Sustainability in the textile industry

The asymmetry of information among producers and consumers is a significant issue, as consumers frequently lack the knowledge and awareness needed to assess the firm's and its products' degree of environmental performance or sustainability of the product (Genç, 2013). The situation is more complicated in textile and apparel crops because there is no clear definition of "good" and "poor" regarding textile sustainability. Eco-labels with third-party certification that provide genuine environmental and social features of production are one method to effectively reduce the asymmetry of knowledge between producers and consumers.

Since the boom of green product releases in the 1980s, environmental modulus, evidence systems, and concomitant environmental labels have evolved to safeguard against greenwashing. Simultaneously, the perceived importance of ecolabels has resulted in their multiplication and a wide range of forms and grades of significance and totality (Choice, 2010). TerraChoice identified the guilt of adoring dummy labels as one of the guilts in 2009. The danger of labels being misinterpreted, or their modality and attributes being misread is growing (UNOPS 2009). According to a TerraChoice analysis (2010), false labeling is becoming more common. 2010 research discovered that more than 32% of 'green' products had a false label, up from 26.8% in 2009. The danger of deceptive labels being used may be minimized by focusing more on labels independently based primarily on many parameters and life cycle considerations.

The effectiveness of such an environmental tag to combat greenwashing tactics and build consumer confidence rests on its capacity, to be honest, understandable, accurate, and verifiable. The Type-I labels offered by ISO 14024 are the most effective (GOTS et al. are examples of several labels used for textiles and apparel goods). However, educating consumers about the meaning of various labels and their contents will take much work. More than thirty percent of items certified by a process based on ISO 14024, according to a TerraChoice assessment from 2010, were without misdemeanor (compared with 4.4 percent of the study-wide results). This statistic illustrates that proper eco-labeling may minimize greenwashing but cannot remove entirely (Koszewska, 2015). In recent years, there has been an increase in consumer interest in ecological or, more generally, sustainable goods. This movement called eco-consumption, green consumption, or sustainable consumption, relies heavily on textile and garment products (Koszewska, 2011).

The textile industry's production chain converts natural fibers, such as cotton and wool, and synthetic fibers into yarn and fabric, then processes them into apparel, textiles, and home goods (Na & Na, 2015). The supply chain begins with extracting fiber from raw materials, degrading the land. The next step is cleaning, which entails removing the cotton fiber from the grain. The cotton is vacuumed into tubes using a vacuum cleaner and then dried to remove moisture and improve the fiber quality. Cleaning follows, using special equipment to remove wood waste and other foreign contaminants (Zabaniotou & Andreou, 2010).

According to industry estimates, 20% of all industrial freshwater contamination is caused by textile refining and dying (Kalliala & Talvenmaa, 2000). In addition, chemicals are used and released throughout the textile refining and dyeing process. If they are not disposed of before refining, they contribute to the mobility and contamination of waste (Powell & Prostko-Bell, 2010).

4.9.1 Textile industry life cycle assessment

Life cycle assessment (LCA) is a comprehensive examination of the environmental impact of products or industrial systems throughout their entire life cycle, as noted by Beton et al. (2014) and Dahllöf (2003). When utilizing LCA to identify eco-friendly and sustainable solutions, the process should encompass several key measures: reducing agribusiness and chemical usage, simplifying crop cultivation by substituting cotton with hemp or flax in the production phase, minimizing energy consumption in the usage phase through lower washing temperatures and tumble drying, and enhancing digestibility in the final phase. There has been a growing consumer interest in environmentally friendly and sustainable products, often referred to as environmental, green products, and sustainable consumerism, primarily driven by the textile and clothing sector, as observed by Koszewska (2011). Manufacturers are constantly seeking ways to distinguish their products, and one popular strategy is green marketing, with terms like 'eco-friendly,' 'eco,' and 'sustainable' becoming commonplace in commercial messages, as highlighted by Chen and Chang (2013). When a company claims the environmental quality of its products without independent third-party validation, it is referred to as a "green claim," according to UNOPS in 2009. Labels with green claims typically fall under ISO's Type II classification. However, many of these claims about the environmental and social attributes of products are often unclear and misleading, leaving room for deceptive practices known as 'greenwash' or 'greenwashing.'

Greenwashing typically occurs when companies inadequately implement environmentally friendly practices and use timely communication to create a false image of their environmental efforts, as discussed by Delmas and Burbano (2011).

Greenwashing can manifest both at the corporate level, where consumers are misinformed about a company's environmental initiatives, and at the product level, where the ecological benefits of a product are misrepresented, as observed by Parguel et al. (2011). The information gap between producers and consumers is a significant challenge. Consumers often lack the knowledge and awareness to evaluate the sustainability and environmental performance of a company and its products, as Genç noted in (2013). This challenge is particularly pronounced in the case of textile and clothing products, where there is a lack of clarity in defining what constitutes "good" and "poor" textile sustainability, as Blackburn pointed out in 2009. Many companies capitalize on these ambiguities to market their products as sustainable, and consumers are often unaware that a meaningful assessment of textile sustainability requires a thorough examination of the product's entire 'cradle-to-grave' life cycle. This complexity is further compounded in the textile and garment industry due to its long, intricate, fragmented, and expansive global supply chains. Even experts struggle to define and communicate "sustainability" in the context of textile and garment products. To combat greenwashing, it is crucial to place more emphasis on third-party validated labels that consider the product's life cycle. The credibility of an environmental label is vital in countering greenwashing and building consumer trust.

4.9.2 The effects of environmental claims on the advertising messages of clothing brands

In recent years, there has been a considerable increase in demand for green products and services. In 2014, more than half of the 18,000 consumers worldwide expressed concern about environmental issues.

Consumers are also more concerned about environmental issues in most countries than in earlier years. Consumers' attitudes about corporate social responsibility commitments were investigated in a study by the American PR firm Edelman (2012). A total of 8000 consumers from 16 countries participated in the survey.

It demonstrated that regardless of the country, consumers believe that environmental responsibility is becoming increasingly important. Furthermore, 85 percent of consumers are eager to switch brands or adjust their behavior to benefit the environment.

Many businesses can get around marketing laws and make greenwashed claims in their advertisements without repercussions. Several tactics are used by businesses to demonstrate that they care about environmental issues. Green advertising is one of these tactics. The concept of green advertising emerged in the 1970s in response to a recession brought on by an increase in oil prices and years of environmental harm that had gone unnoticed.

People were quickly reminded that resources were finite, and their use had significant environmental repercussions. Companies tried to keep up with the green trend and addressed customer concerns by including green messaging in their marketing.

Green advertising, according to Banerjee et al. (1995), is an advertisement that fits one or more of the following criteria:

1. Addresses the link between a product/service and the biophysical environment, either explicitly or implicitly.
2. Promotes a green lifestyle, whether a product or service is highlighted.

3. Projects an image of environmental stewardship inside the company.
4. According to Pranee (2010), green advertising must be legal and truthful, as well as comply with all environmental legislation and standards. Firms do not always adhere to these statements while still adhering to the established advertising standards.

5 Impacts of the textile industry on the environment

Although the textile sector contributes to job creation, it is one of the most polluting industries. Textile refining and dyeing operations account for around 35% of all chemicals discharged into the environment (Thiry, 2011). Three trillion gallons of fresh water are used to make 60 billion kg of fabric yearly, contributing to water problems all around the world (Exchange, 2010a).

According to the worldwide fund for nature, it requires around 8500 gallons of water to produce one kilogram of cotton, equal to one pair of blue jeans. With new difficulties such as climate change, resource scarcity, a demanding regulatory framework, and the need for sustainable textiles, the issue of environmental degradation caused by textile production should be addressed urgently (Bönte & Dienes, 2013; Da Silva & Teixeira, 2008; Jeswani et al., 2008).

Environmental consequences in the textile business can be grouped into areas like using harmful chemicals in the manufacturing of raw materials, fertilizers, insecticides, and pesticides, or diffusion in the production of synthetic fibers. Solid wastes and chemicals from the manufacture of natural fiber yarn are discharged into the sea during the dyeing and finishing process (Reddy & Ray, 2011).

Furthermore, the environment is impacted by the transportation of items across the textile supply chain. As a result, energy is used to power machines, mechanize outdated enterprises, and transport products (Defra, 2008).

The air pollution created during manufacturing poses serious health hazards, resulting in frequent occupational ailments among cotton and hemp workers (Kane, 2001). The consequences of water usage, including the textile supply chain, cause fossil energy depletion, climate change, ozone depletion, photochemical oxidant generation, and other issues. Laundry, tumble drying, and ironing are included in the usage phase. In particular, the detergent and energy used for the washing process have contributed significantly to toxicity indicators linked to humans and water ecosystems. As a result of the influence on marine and freshwater toxicity, ecological diversity may suffer. The usage phase is more important than the production and processing stages due to the high-water consumption for washing. The environmental effects of this phase are affected by variables like frequency of washing, degree of washing, and drying processes. Drying and ironing is essential when considering the frequency, temperature, and duration of a procedure.

These characteristics may vary depending on the fiber qualities, consumption region, and consumer behavior of each product. For instance, synthetic materials are often washed, dried, and pressed at lower temperatures. Incineration, landfilling, and recycling operations are all included in the end-of-life phase. In comparison to the preceding phases, this one has minimal environmental consequences. Furthermore, recycling and energy recovery technologies might have a detrimental impact. Because of prints on clothing, composite fabrics, waterproof coatings, and other technological hurdles, recycling is hampered.

5.1 Pollution and water consumption

The current apparel cycle (from manufacture to consumption) is inefficient and polluting. The production of fibers, the manufacturing, usage, and disposal of garments all need vast quantities of water but leave fiber and chemical residues in water sources.

Every year, around 93 cubic meters of water are used in textile manufacture, which equates to 37 million Olympic-sized swimming pools (Berger et al., 2021). Additionally, it requires around 2720 L of water to produce one cotton T-shirt, which is the same as just what an adult would consume in three years. Even throughout different usage cycles, such as cleaning, water consumption persists. This excessive usage is immediately noticed in areas where water is scarce due to dyeing and finishing during manufacture. The textile industry accounts for approximately 20% of global water contamination.

6 ReCiPe method simulation of textile industries' green washing

Controlling greenwashing in the textile industry can be challenging, as it often involves detecting and correcting deceptive or misleading claims about the environmental performance of products Fig. 9. However, some steps can be taken to mitigate the risks of greenwashing, such as implementing transparency and certification programs, conducting independent verification of environmental claims, and promoting consumer education. In terms of developing a MATLAB program to help control greenwashing, one approach could be to create a tool to evaluate the environmental performance of textile products based on pre-defined criteria. The present research's programming is done in MATLAB 2019b (Paluszek & Thomas, 2019).

This study aims to assess the environmental impacts of textile material, with a particular focus on the potential greenwashing practices that might occur in the industry. To achieve this objective, the research uses the LCA methodology, a well-established approach for quantifying the environmental impacts of products and processes over their entire life cycle. In particular, the investigation applies the ReCiPe method. This widely recognized and commonly used LCA impact assessment method calculates the impacts in various environmental categories, including climate change, human toxicity, and ecosystem quality. To conduct the LCA, the study first defines the functional unit, the amount of material we will assess. The functional unit is selected to be 1 kg of textile material in this case. The data are collected on the different life cycle stages of the material, including raw material extraction, processing, manufacturing, use, and disposal. The research quantifies the CO2eq emissions associated with 1 kg of material for each stage. Specifically, the efforts use the following variables: (1) raw_material_extraction: kg CO2eq emissions per kg of raw material extraction, (2) processing: kg CO2eq emissions per kg of processing, (3) manufacturing: kg CO2eq emissions per kg of manufacturing, (4) use: kg CO2eq emissions per kg of use and (5) disposal: kg CO2eq emissions per kg of disposal.

The research assumes that these variables remain constant over time. However, the current practices introduce random fluctuations to each variable with a 30% deviation to account for possible variability in the system. The research then defines the time frame of the simulation to be one-year or 12 months. For each month, the study calculates the environmental impacts of the material in each life cycle stage using Eqs. (1–5).

$$\text{impact\_raw\_material\_extraction}(i) = \text{functional\_unit} * \text{raw\_material\_extraction\_fluct} \tag{1}$$

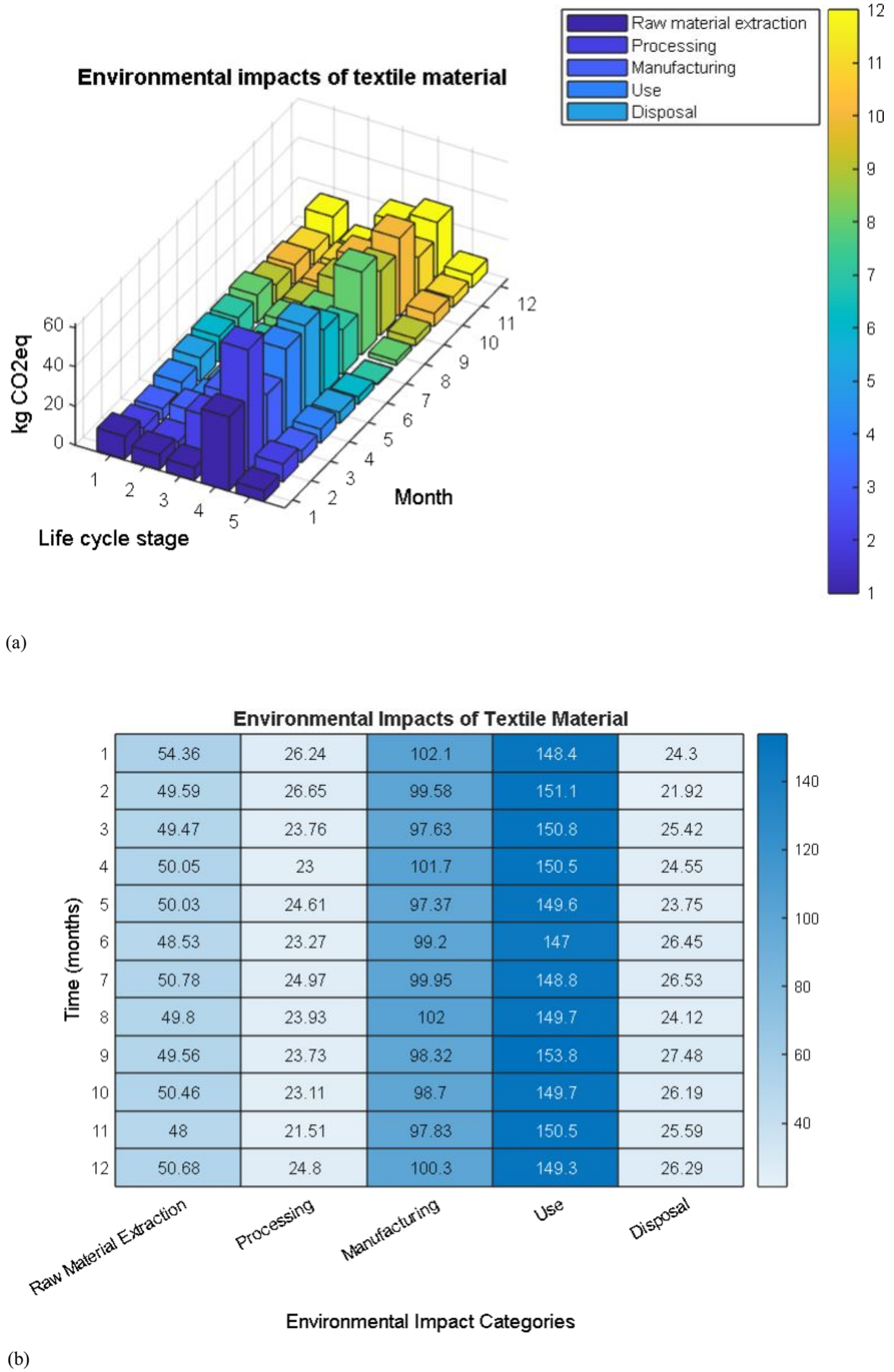


Fig. 9 The outcomes of ReCiPe method simulation based on **a** bar chart and **b** heatmap expressions

$$\text{impact\_processing}(i) = \text{functional\_unit} * \text{processing\_fluct} \tag{2}$$

$$\text{impact\_manufacturing}(i) = \text{functional\_unit} * \text{manufacturing\_fluct} \tag{3}$$

$$\text{impact\_use}(i) = \text{functional\_unit} * \text{use\_fluct} \tag{4}$$

$$\text{impact\_disposal}(i) = \text{functional\_unit} * \text{disposal\_fluct} \tag{5}$$

, where i is the index for the current month, and the fluct suffix indicates the randomly fluctuating variable. The results of these calculations are stored in arrays for each life cycle stage and each month. Finally, we calculate the total environmental impact for each month by summing the impacts across all life cycle stages (Eq. 6).

$$\begin{aligned} \text{total\_impact}(i) = &\text{impact\_raw\_material\_extraction}(i) + \text{impact\_processing}(i) \\ &+ \text{impact\_manufacturing}(i) + \text{impact\_use}(i) + \text{impact\_disposal}(i) \end{aligned} \tag{6}$$

The simulation is run over one year, with data collected every 12 months. The program initializes arrays to store the results for each month and loops through each month, adding random fluctuations to each unit of environmental impact with a 30% deviation, then calculates the total environmental impact for that month. The results are then displayed and plotted as a 3D bar chart. The numerical outcomes of this simulation will vary each time it is run due to the random fluctuations added to each unit of environmental impact with a 30% deviation. However, the general trend of the outcomes is that the environmental impact is highest during the use phase of the material, with values ranging from 29.5 to 33.3 kg CO2eq per month, followed by manufacturing, with values ranging from 18.8 to 21.4 kg CO2eq per month. Raw material extraction, processing, and disposal have the lowest environmental impacts, with values ranging from 8.5 to 12.0 kg CO2eq per month for raw material extraction, 4.6 to 6.1 kg CO2eq per month for processing, and 4.4 to 6.6 kg CO2eq per month for disposal.

Implementing a MATLAB program to control greenwashing in the textile industry involves not only technical considerations but also broader implications. The program's dynamic nature must adapt to evolving industry practices, necessitating continuous monitoring and updates (Pedersen & Andersen, 2023). The 30% deviation introduced aims to capture real-world variability, emphasizing the need for ongoing assessment criteria adjustments. Collaboration with industry stakeholders and regular certification program reviews enhances the program's ability to identify greenwashing. Communicating the program's transparency effectively to consumers empowers them to make informed choices and actively support sustainability. Achieving a balance between technical robustness, adaptability, and clear communication is crucial for the program's long-term success in combating greenwashing in the textile industry (von Flüe et al., 2024).

6.1 Life cycle cost (LCC) simulation of textile industries' greenwashing

This section of the study is focused on the implementation of a classical conditioning experiment in a computational model (using MATLAB 2019b). The purpose of the experiment is to simulate the learning of stimulus-outcome associations in different contexts. The model employs the Rescorla-Wagner learning algorithm, which updates the associative strengths of stimuli and outcomes based on the prediction error (Ishimoto et al., 2023). The experiment consists of 50 trials in which two stimuli (*a* CS+ and a CS−) are presented in different contexts. The associative strengths between stimuli and contexts (V matrix) and between stimuli and outcomes (*W* matrix) are initialized to zero. During each trial, a stimulus is randomly selected and presented, and the outcome is recorded. The outcome is determined by the stimulus type (CS+ or CS−) and is randomly chosen based on the probabilities of the functional outcomes. After the outcome is recorded, the associative strengths of the stimuli and outcomes are updated using the Rescorla–Wagner learning rule. The prediction error is computed as the difference between the actual outcome and the predicted outcome based on the associative strengths. The associative strengths are then updated by multiplying the learning rate (alpha) by the prediction error and the input stimuli. The input stimuli are either the context or the selected stimulus, depending on the associative strength being updated.

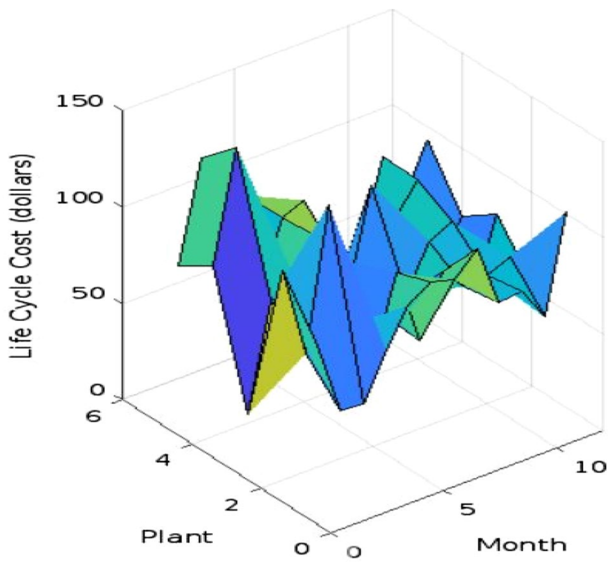
The *V* and *W* matrices are updated after each trial, and their values are stored in *V*_history and *W*_history vectors, respectively. These vectors are then used to plot the associative strengths of the stimuli and outcomes over time. The Rescorla–Wagner learning rule can be mathematically shown in Eqs. (7) and (8).

$$\text{delta}V = \text{alpha} * (\text{delta}-\text{sum}\ (\exp(V(:,\text{context})). * W(:,\text{outcome}))) \tag{7}$$

$$\text{delta}W = \text{alpha} * (\text{delta}-\exp\ (V(\text{stimulus},\ \text{context})) * W(\text{stimulus},\ \text{outcome})) \tag{8}$$

, where delta*V* and delta*W* are the changes in associative strengths for stimulus-context and stimulus-outcome pairings, respectively. Alpha is the learning rate, delta is the prediction error, *V* is the stimulus-context associative strengths matrix, and *W* is the stimulus-outcome associative strengths matrix. The softmax rule is used to select the stimulus during each trial, and the outcome is chosen randomly based on the probabilities of the available outcomes. The outcomes of simulation for five plants are shown as per Fig. 10. With the

Fig. 10 The result of LCC analysis for greenwashing assessment of five textile plants



application of this outcomes, the behavior of each plant can be evaluated with the greenwashing aspects and also, it's a nice point of view for decision-making of managers.

The implications of employing a computational model to implement a classical conditioning experiment are multifaceted. Beyond the technical nuances of the Rescorla-Wagner learning algorithm, the study accentuates the adaptability of the model in replicating real-world learning processes. The emphasis on careful parameter selection, especially the learning rate (alpha), speaks to the critical need for accuracy in mimicking actual behaviors. The incorporation of the softmax rule for stimulus selection and random outcome determination enhances the model's ecological validity by capturing the inherent unpredictability of behavior. The outcomes showcased for five plants in Fig. 10 not only exemplify the model's practical utility but also underscore its potential in evaluating greenwashing aspects in plant behavior. This not only provides valuable insights for managerial decision-making but also addresses the broader implications of how environmental stimuli influence responses and contribute to the identification of potential deceptive practices. The study's integration of computational modeling with real-world applications stands out as a significant contribution, shedding light on complex behavioral phenomena, particularly within the realm of greenwashing, and offering practical implications for decision-makers (Rajesh, 2023; Wang et al., 2023).

6.2 Eco-labeling simulation and green washing

The purpose of this simulation is to calculate an eco-label score for a textile product based on its environmental performance criteria in MATLAB 2019b, which are defined as follows:

- CO2_threshold: The maximum allowable CO2 emissions in kg per unit of product
- Water_threshold: The maximum allowable water consumption in liters per unit of product (Banerjee, 2023)

The environmental impact of the textile product is measured in terms of CO2eq emissions and water consumption for each stage of the product's life cycle, including raw material extraction, processing, manufacturing, use, and disposal. These impacts are shown as vectors:

- raw_material_extraction_emissions: kg CO2eq emissions per kg of raw material extraction for each plant
- processing_emissions: kg CO2eq emissions per kg of processing for each plant
- manufacturing_emissions: kg CO2eq emissions per kg of manufacturing for each plant
- u* se_emissions: kg CO2eq emissions per kg of use for each plant
- disposal_emissions: kg CO2eq emissions per kg of disposal for each plant
- water_consumption: liters of water per unit of product for each plant

The program then generates a one-year time series for each plant, which represents the product's environmental impact for each month of the year, including a 20% random fluctuation in each month. This is represented as a 12×5 matrix: time_series: 12 months $\times$ 5 plants. Based on the environmental performance criteria and the environmental impacts, the program calculates an eco-label score for each plant and each month. As a structure of eco-label score computations, for each plant and each month, the total CO2eq emissions are calculated as the sum of the emissions from raw material extraction, processing, manufacturing, use, and disposal. If the total CO2eq emissions are less than or equal to the CO2_threshold and the water consumption is less than or equal to the water_threshold, the eco-label score is 5, which represents the maximum score for meeting all criteria. If the total CO2eq emissions are less than or equal to the CO2_threshold or the water consumption is less than or equal to the water_threshold, the eco-label score is 2.5, which represents a partial score for meeting one of the criteria. If the total CO2eq emissions are greater than the CO2_threshold and the water consumption is greater than the water_threshold, the eco-label score is 0, which represents a failure to meet the criteria. Finally, the program generates 3D plots of the eco-label scores for each plant and each month. Greenwashing refers to the practice of making false or misleading claims about the environmental benefits of a product or service. Eco-labeling is a way to provide consumers with information about the environmental impact of a product or service and to help them make informed purchasing decisions. The methodology used in this program can help to prevent greenwashing by providing a standardized and objective way to measure the environmental impact of a textile product. By setting clear environmental performance criteria and calculating an eco-label score based on these criteria, the program provides a transparent and reliable way to communicate the environmental impact of the product to consumers. This can help to promote consumer trust and reduce the risk of greenwashing. The outcomes of simulation practices for five different companies are shown in Fig. 11.

The eco-label scores are calculated for each plant and each month of the year. The eco-label score is a measure of how well the product meets the environmental performance

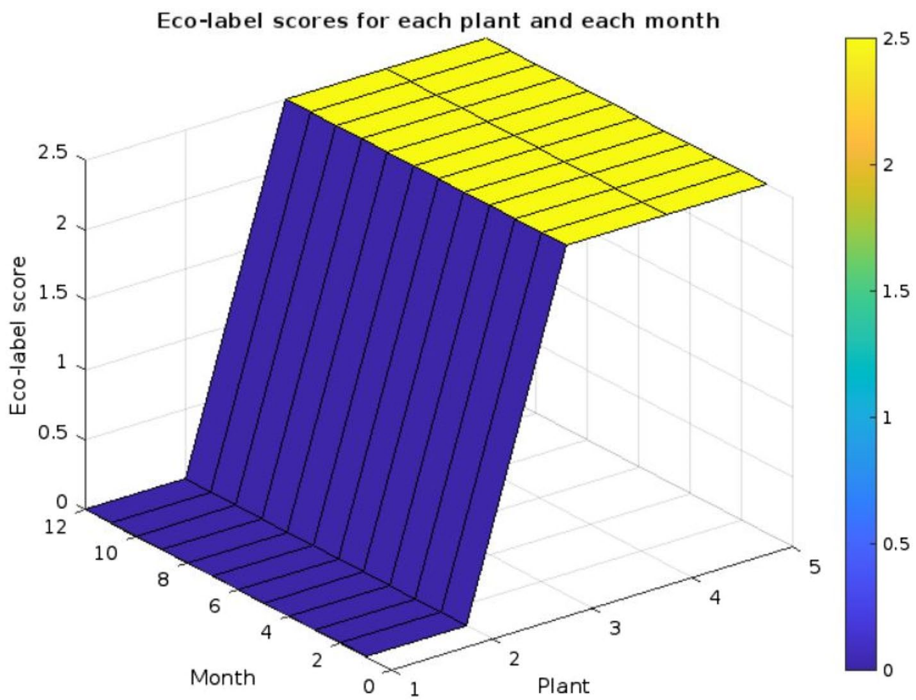


Fig. 11 Eco-labeling simulation of different companies in a year

criteria set for eco-labeling. The score ranges from 0 to 5, where 0 indicates that the product fails to meet the criteria, and five indicates that the product meets all criteria. If the total emissions of CO2 equivalents and water consumption in a unit of product meet the criteria, the product scores 5. If the product meets only one of the criteria, it scores 2.5. If it fails to meet both criteria, it scores 0.

The eco-labeling simulation aims to provide an executive tool for assessing the environmental impact of textile products. By employing predetermined environmental criteria, the program calculates eco-label scores based on CO2eq emissions and water consumption throughout the product's life cycle. The scores, ranging from 0 to 5, offer a clear indication of compliance with environmental standards. The program's ability to generate one-year time series for each plant, incorporating random fluctuations, enhances its adaptability to dynamic real-world scenarios. Executives can utilize the 3D plots of eco-label scores for different companies, as shown in Fig. 11, to make informed decisions and promote transparent communication of a product's environmental impact to consumers. Ultimately, this simulation serves as a valuable executive tool for preventing greenwashing, fostering consumer trust, and guiding sustainable decision-making in the textile industry (Buckley, 2023; Plakantonaki et al., 2023).

6.3 Managerial insights into greenwashing

Greenwashing, which refers to the practice of making exaggerated or false claims about the environmental benefits of a product or service, is a major concern in the textile industry. As consumers become more environmentally conscious, textile companies are under pressure to adopt sustainable practices and offer eco-friendly products. However, some companies engage in greenwashing to attract customers without actually making significant changes to their practices. Sustainable investing has emerged as a solution to combat greenwashing by encouraging companies to prioritize sustainability and transparency in their operations. Sustainable investors can use their financial power to support companies that have a proven track record of sustainability and avoid investing in those that engage in greenwashing. This approach not only helps promote more sustainable practices in the textile industry but also sends a message to companies that sustainability is becoming an increasingly important factor in financial decision-making.

Environmental, social, and governance (ESG) factors have become increasingly important in the investment world. Investors are no longer just focused on financial returns but also on the broader impact of their investments on society and the environment. As a result, companies are under pressure to demonstrate their commitment to sustainability and responsible practices and to report on their ESG performance. However, this has also led to an increase in greenwashing, which refers to companies making false or exaggerated claims about their environmental or social performance to attract investors. To address this issue, there are various ESG frameworks and standards that have been developed to help investors identify companies that are genuinely committed to sustainability and responsible practices. For example, the global reporting initiative (GRI) provides guidelines for companies to report on their ESG performance, while the Sustainability Accounting Standards Board (SASB) provides industry specific ESG standards for companies to follow. Investors can also use various tools and resources to assess a company's ESG performance, such as ESG rating agencies and ESG-focused exchange-traded funds (ETFs). However, it is important to note that these tools and resources are not perfect and can sometimes be subject to their own biases and limitations. Ultimately, the best way to avoid greenwashing and ensure that investments are aligned with ESG principles is through thorough due diligence and engagement with companies. This includes examining a company's ESG reports and engaging with company management to understand their commitment to sustainability and responsible practices. By taking a proactive approach to ESG investing and avoiding greenwashing, investors can help drive positive change and promote a more sustainable and equitable future.

In a study conducted in 2019 on companies worldwide Fig. 12, it was found that firms with higher market capitalizations generally have higher scores in environmental, social, and governance (ESG) assessments. However, this does not necessarily mean that larger companies are more socially and environmentally responsible than smaller ones. Rather, the trend is likely since larger companies have more resources to allocate toward ESG integration. ESG rating providers heavily rely on disclosed information from companies and follow a framework for their assessments. Larger companies can easily align their processes with these frameworks and publicly report their ESG efforts. This emphasizes the need for standardized ESG assessments and resources to support smaller companies in adapting to ESG standards. Future research should explore the relationship between company size and ESG scores and identify strategies to support smaller companies in improving their ESG performance.

Despite the link between market capitalization and ESG scores, there are significant variations in ESG ratings among some of the world's largest companies, reflecting differences over specific ESG concerns Fig. 13. Surprisingly, even companies known for their commitment to sustainability, like Tesla, exhibit disagreement over their ESG scores. Similarly, tech giants like Apple and Facebook demonstrate significant variance in ESG scores. Interestingly, the highest-performing companies in terms of ESG ratings are Taiwan Semiconductor Manufacturing Company (TSMC) and Nvidia, which are high-tech manufacturers of computer chips. However, the products and services enabled by these chips are

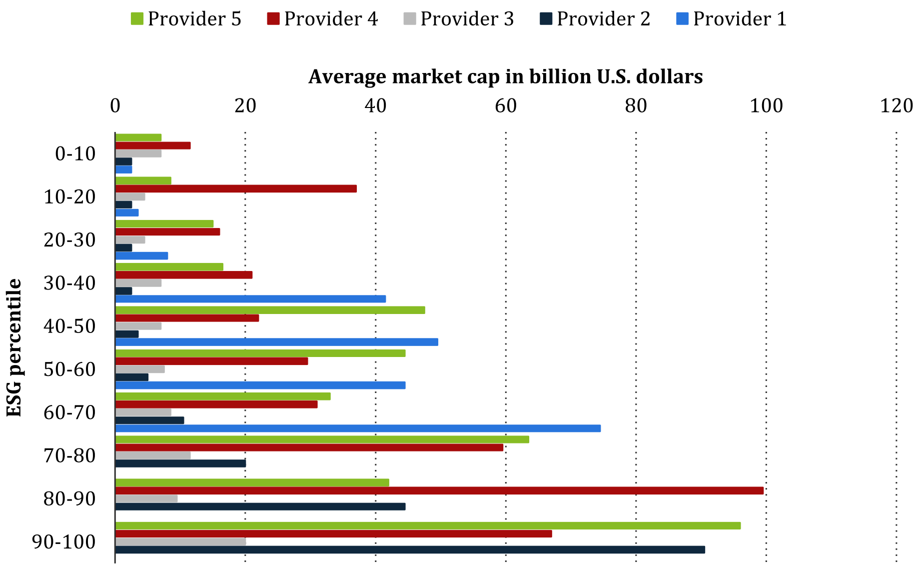


Fig. 12 ESG percentile of different companies based on market size in a study (Bloomberg; MSCI; OECD; Refinitiv; Statista estimates; ID 1268165)

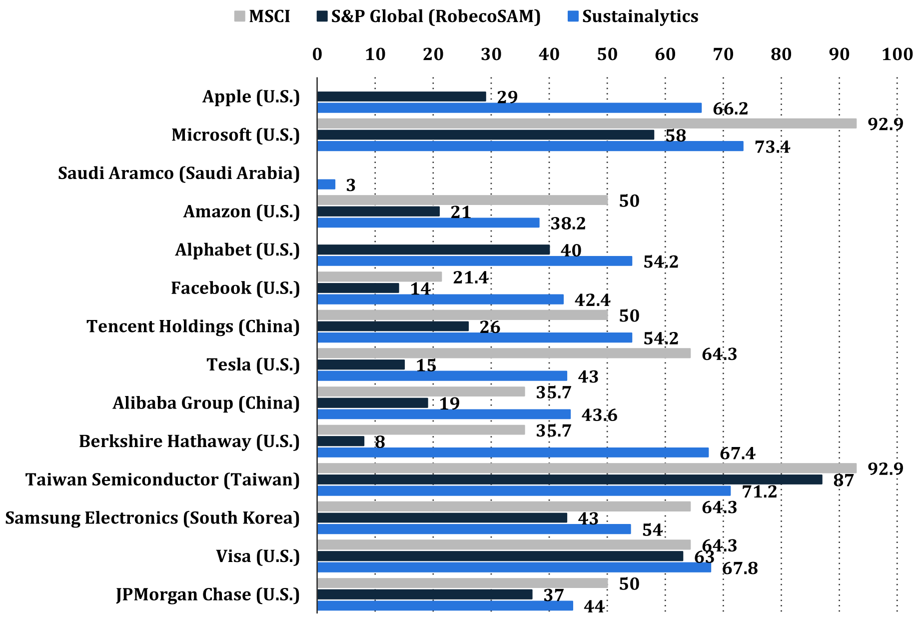


Fig. 13 ESG score of the most businesses in the world (MSCI; S&P Global; Statista; Sustainalytics; ID 1268534)

offered by companies with lower ESG scores, raising an important question about whether such investments are genuinely sustainable, since their downstream effects may enable less sustainable products and services. This suggests that further research is needed to explore the relationship between specific ESG concerns and the variations in ESG ratings among companies and investigate the downstream effects of companies' products and services on sustainability.

7 Discussion

Due to the increase in environmental pollution, various companies and industries have been looking to develop green products that cause less environmental damage. Still, in the meantime, some companies and individuals spread false information or misleading advertisements through greenwashing. By an organization to present an overly optimistic image of the company regarding environmental practices.

The textile industry is one of the industries in different stages, from production to distribution and transportation.

It causes pollution. The textile industry recently turned to green production technology to reduce pollution. With this technology, production costs are significantly saved due to low production.

Therefore, green technology and economic rotation are a more practical approach for the durable and environmentally friendly textile industry.

A non-profit organization called the global organic textile standard (GOTS) was established to guarantee the quality of the textile products produced in 2006. This organization is responsible for certifying natural fibers from cotton to hemp. The organization (GOTS) differentiates the company from other competitors and provides the possibility of justifying the higher price of products for customers.

According to the survey, 81% of people firmly believe that businesses help to improve the environment. One issue that has caused industries and companies to be less inclined toward green production is the price factor.

Since, consumers do not want to buy textile products that are produced in a green economic way due to the high price, businesses change to cheaper options.

According to Fig. 14, the importance of LCA, LCC analysis, and eco-labeling in the textile industry cannot be overstated in the context of controlling greenwashing. These methodologies serve as critical tools in the battle against deceptive environmental claims. LCA enables a comprehensive evaluation of the environmental impacts of textile products throughout their entire life cycle, from raw material extraction to disposal. By quantifying emissions and resource consumption, it provides an objective and transparent assessment of a product's environmental performance. Concurrently, LCC analysis factors in the economic aspects, offering insights into the true cost implications of sustainable practices. Eco-labeling, on the other hand, provides a standardized way to communicate a product's environmental attributes to consumers, ensuring that they receive accurate and reliable

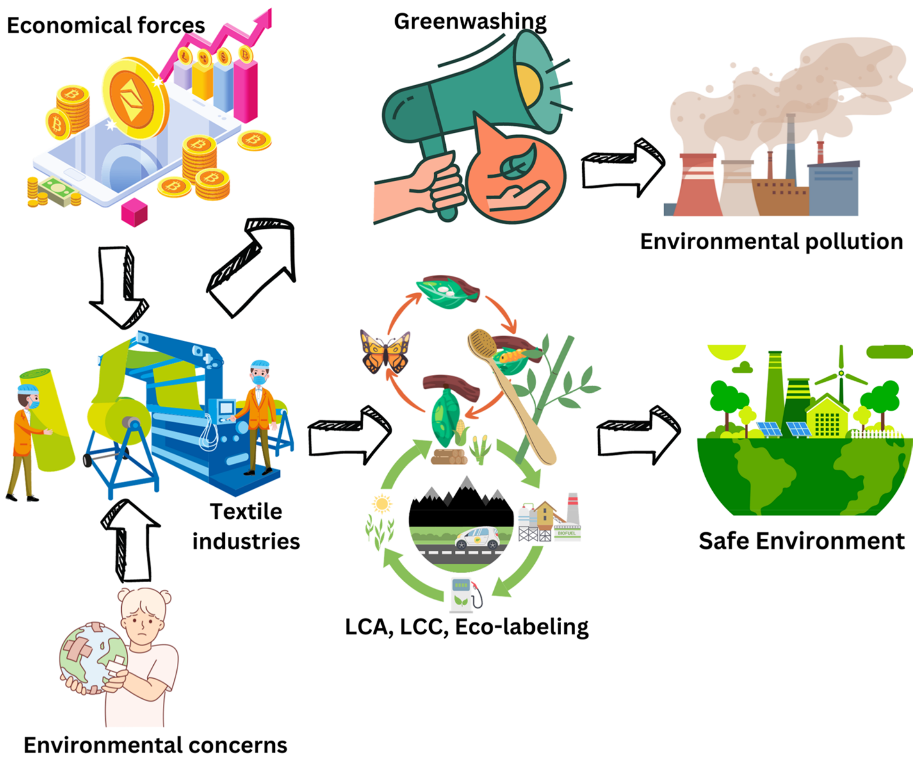


Fig. 14 The scheme of the present study concepts and effects

information. Together, these methodologies empower stakeholders to distinguish genuine sustainability efforts from greenwashing practices, fostering transparency, trust, and informed decision-making in the textile industry.

The findings of this study hold significant theoretical implications for future research in the realms of greenwashing, sustainability, and the textile industry. Firstly, delving deeper into the psychology of consumer behavior and perception when confronted with greenwashing strategies offers a promising avenue. Further research in this area can provide a more nuanced understanding of how consumers react to deceptive environmental claims, shedding light on the underlying cognitive and emotional processes that influence their decision-making. Moreover, exploring the effectiveness of regulatory mechanisms and legal frameworks in curbing greenwashing practices, particularly within the textile industry, can uncover gaps and areas for policy improvement, advancing our knowledge of the intersection between environmental regulation and corporate behavior. Additionally, investigating the role and impact of third-party certifications and eco-labeling in promoting genuine sustainability practices within the textile sector offers a rich area for exploration. Understanding the mechanisms through which these certifications shape consumer trust and influence industry behavior can contribute substantially to the scholarly discourse on sustainable practices and corporate responsibility.

From a practical standpoint, this study underscores the urgency of implementing industry-wide initiatives to combat greenwashing within the textile sector. Future research should explore the development and deployment of standardized eco-labeling practices and their influence on consumer preferences and industry conduct. Gaining insights from the experiences of companies that have successfully transitioned towards authentic sustainability practices can offer valuable lessons for other firms aspiring to follow suit. Additionally, the study highlights the importance of LCA and LCC methodologies in evaluating both the environmental and economic aspects of textile products. Subsequent research can delve into how these assessment techniques can be effectively integrated into industry decision-making processes, with a focus on identifying cost-efficient and sustainable strategies that benefit both businesses and the environment.

Recognizing the multifaceted nature of sustainability and greenwashing, future studies stand to benefit significantly from interdisciplinary collaborations. Partnerships between environmental scientists, psychologists, economists, and legal experts can foster a more comprehensive understanding of the phenomenon and its mitigation strategies. Such collaborations can illuminate the intricate interplay between psychological, economic, legal, and environmental factors that underpin greenwashing and sustainability practices. Furthermore, examining the transferability of findings and best practices from the textile industry to other sectors grappling with similar challenges in environmental sustainability and greenwashing can broaden the scope of future research. By extrapolating lessons learned from the textile industry, researchers can contribute to more comprehensive and globally applicable solutions that address the pervasive issue of greenwashing and promote genuine sustainability across various sectors.

The study has several limitations that warrant consideration. Firstly, its findings are predominantly centered on the textile industry, potentially limiting their applicability to other sectors or industries with distinct dynamics, challenges, and consumer behaviors related to greenwashing and sustainability. Caution should be exercised when extrapolating these findings to contexts outside the textile industry. Secondly, the reliance on existing data sources, industry laws, and standards introduces data limitations. Variability in data availability and quality could affect the accuracy and comprehensiveness of the analysis. Additionally, the study's historical data focus (covering the period from 1979 to 2014) may not fully capture recent developments and changes in the industry, particularly in the rapidly evolving field of sustainability. The study touches upon the complexity of greenwashing detection, but does not delve deeply into the intricate methods and challenges associated with identifying and quantifying greenwashing practices. Greenwashing's subtle and multifaceted nature makes comprehensive assessment challenging, suggesting the need for future research to explore effective detection methods.

Furthermore, the study primarily concentrates on industry practices, environmental impact assessments, and eco-labeling, offering limited insights into consumer perspectives, attitudes, and behaviors regarding greenwashing and sustainable consumption. Understanding these consumer motivations is crucial to addressing the demand side of greenwashing effectively. While the study highlights the potential benefits of implementing eco-labeling practices, it does not thoroughly investigate potential trade-offs or unintended consequences that may arise from such initiatives. Future research should explore the economic and operational challenges companies may encounter when adopting sustainability measures. The temporal scope of the study, which spans from 1979 to 2014, may not fully capture the most recent developments and shifts in the textile industry's sustainability practices. An updated analysis could provide insights into evolving trends and strategies. Lastly, the study focuses on the textile industry's global aspects, potentially overlooking regional or cultural variations in consumer behaviors, regulatory frameworks, and sustainability practices. Future research that considers these contextual factors could provide a more nuanced understanding of greenwashing in diverse settings.

8 Conclusion

This research investigates the critical issue of greenwashing and its implications on the environment, with a specific focus on its connection to the textile industry. As environmental concerns rise, companies often falsely present their products as eco-friendly, contributing to a misleading positive image through greenwashing practices. The study emphasizes the prevalence of greenwashing, particularly when there's a noticeable gap between an organization's environmental claims and its actual performance. Textile industry, vital for the global economy, poses environmental challenges—intense resource use and wastewater generation, exacerbating water scarcity. Textile industry, despite adopting green practices, still has a substantial environmental impact. Research highlights greenwashing challenges and proposes solutions: enhanced transparency, certifications, independent verification, and consumer education.

The study utilizes life cycle assessment (LCA) and ReCiPe methods, focusing on 1 kg of textile material across life cycle stages. Findings reveal the use phase has the highest environmental impact, followed by manufacturing, raw material extraction, processing, and disposal. Additionally, the research introduces a novel approach, incorporating classical conditioning into a computational model to simulate life cycle cost, offering potential for assessing the financial aspects of sustainable practices in the textile industry. In conclusion, the study addresses greenwashing challenges in the textile sector, proposing solutions and innovative methods to evaluate both environmental and financial impacts, thereby promoting sustainability.

Future studies could explore the application of machine learning computations to enhance waste management control in textile industries and enable smart detection of corruption, mitigating potential issues. Additionally, considering metaheuristic algorithms as innovative approaches may offer novel ideas for implementing sustainable supply chains in the textile industry, focusing on effective control of greenwashing practices.

Author contributions KM involved in conceptualization, writing-original draft preparation, writing—review and editing; revised, EK involved in conceptualization, writing—review and editing, supervision and feedback, funding acquisition, revised, SR involved in conceptualization, writing—review and editing funding acquisition resources, project administration; AC involved in writing—review and editing, All authors read and approved the final manuscript, MG involved in conceptualization, writing-original draft preparation, writing—review and editing, software; revised.

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Data availability Not applicable.

Declarations

Conflict of interest All other authors declare no competing interests.

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References

Adamkiewicz, J., Kochańska, E., Adamkiewicz, I., & Łukasik, R. M. (2022). Greenwashing and sustainable fashion industry. *Current Opinion in Green and Sustainable Chemistry, 38*, 100710.

Aktar, M. A. (2014). Green insights of textile industry in Bangladesh: A case study on Mozart Knitting Ltd. *Global Disclosure of Economics and Business, 3*(1), 93–108.

Akturan, U. (2018). How does greenwashing affect green branding equity and purchase intention? An empirical research. *Marketing Intelligence & Planning, 36*, 809–824.

Alexa, L., et al. (2021). Fast fashion—An industry at the intersection of green marketing with greenwashing. Proceedings of the 7thInternational Symposium "Technical Textiles—Present and Future", Iasi, Romania, 263–268

Amini, M. H., Arab, M., Faramarz, M. G., Ghazikhani, A., & Gheibi, M. (2021). Presenting a soft sensor for monitoring and controlling well health and pump performance using machine learning, statistical analysis, and Petri net modeling. *Environmental Science and Pollution Research, 8*, 1–17.

Asif, M. H., Zhongfu, T., Irfan, M., Ahmad, B., & Ali, M. (2023). Assessing eco-label knowledge and sustainable consumption behavior in energy sector of Pakistan: An environmental sustainability paradigm. *Environmental Science and Pollution Research, 30*(14), 41319–41332.

Banerjee, A. (2023). Eco-labeling. In *Dictionary of ecological economics* (pp. 145–146). Edward Elgar Publishing.

Banerjee, S., Gulas, C.S., & Iyer, E. (1995). Shades of green: a multidimensional analysis of environmental advertising. *Journal of Advertising, 24*(2), 21–31.

Barnes, L., & Gaynor, L. (2010). Fast fashion in the retail store environment. *International Journal of Retail & Distribution Management, 38*, 760–772.

Baydar, G., Ciliz, N., & Mammadov, A. (2015). Life cycle assessment of cotton textile products in Turkey. *Resources, Conservation and Recycling, 104*, 213–223.

Beall, A. (2020). *Why clothes are so hard to recycle?*. BBC Future. Future. Retrieved from https://www.bbc.com/future/article/20200710-whyclothes-are-so-hard-to-recycle

Berger, M., Campos, J., Carolli, M., Dantas, I., Forin, S., Kosatica, E., Kramer, A., Mikosch, N., Nouri, H., & Schlattmann, A. (2021). Advancing the water footprint into an instrument to support achieving the SDGs–recommendations from the "Water as a Global Resources" research initiative (GRoW). *Water Resources Management, 35*(4), 1291–1298.

Berthelot, S., Cormier, D., & Magnan, M. (2003). Environmental, disclosure researchi: Feview and synthesis. *Journal of Accounting Literature, 22*, 1–44.

Beton, A., Dias, D., Farrant, L., Gibon, T., Le Guern, Y., Desaxce, M., Perwueltz, A., Boufateh, I., Wolf, O., & Kougoulis, J. (2014). *Environmental improvement potential of textiles (IMPRO-Textiles)*. European Commission, European Commission, Retrieved from https://op.europa.eu/en/publication-detail/-/publication/f8d0def8-4fd5-4d84-a308-1dfa5cf2e823/language-en

Bhattacharya, C. B., & Sen, S. (2004). Doing better at doing good: When, why, and how consumers respond to corporate social initiatives. *California Management Review, 47*(1), 9–24.

Blackburn, R. (2009). *Sustainable textiles: Life cycle and environmental impact*. Elsevier.

Bönte, W., & Dienes, C. (2013). Environmental innovations and strategies for the development of new production technologies: Empirical evidence from Europe. *Business Strategy and the Environment, 22*(8), 501–516.

Bowen, F., & Aragon-Correa, J. A. (2014). *Greenwashing in corporate environmentalism research and practice: The importance of what we say and do* Sage Publications Sage CA: Los Angeles, CA. 27, 107–112.

Buckley, R. (2023). Sector-scale proliferation of CSR quality label programs via mimicry: The Rotkäppchen effect. *Sustainability, 15*(14), 10910.

Busch, T., & Hoffmann, V. H. (2009). Ecology-driven real options: An investment framework for incorporating uncertainties in the context of the natural environment. *Journal of Business Ethics, 90*(2), 295–310.

Chae, Y., & Hinestroza, J. (2020). Building circular economy for smart textiles, smart clothing, and future wearables. *Materials Circular Economy, 2*(1), 1–4.

Change, N. C. (2018). The price of fast fashion. *Nature Clinical Practice Endocrinology & Metabolism, 8*, 1–1.

Chen, Y. S., Lin, C. L., & Chang, C. H. (2014). The influence of greenwash on green word-of-mouth (green WOM): the mediation effects of green perceived quality and green satisfaction. *Quality & Quantity, 48*, 2411–2425

Chen, Y.-S., Tien, W.-P., Lee, Y.-I., & Tsai, M.-L. (2016). Greenwash and green brand equity. In *2016 Portland International Conference on Management of Engineering and Technology (PICMET)* (pp. 1797–1803). IEEE.

Chen, H., Bernard, S., & Rahman, I. (2019). Greenwashing in hotels: A structural model of trust and behavioral intentions. *Journal of Cleaner Production, 206*, 326–335.

Chen, X., Memon, H. A., Wang, Y., Marriam, I., & Tebyetekerwa, M. (2021). Circular economy and sustainability of the clothing and textile industry. *Materials Circular Economy, 3*(1), 1–9.

Chen, Y.-S., & Chang, C.-H. (2013). Greenwash and green trust: The mediation effects of green consumer confusion and green perceived risk. *Journal of Business Ethics, 114*(3), 489–500.

Choice, T. (2010). *The sins of greenwashing: home and family edition*. Underwriters Laboratories.

Cliath, A. G. (2007). Seeing shades: Ecological and socially just labeling. *Organization & Environment, 20*(4), 413–439.

McKinsey & Company. (2023). The state of fashion. https://www.mckinsey.com/

Da Silva, R. V., & Teixeira, N. (2008). Environmental business strategy: The Portuguese case. *Business Strategy and the Environment, 17*(3), 208–218.

Dahl, R. (2010). Greenwashing: do you know what you're buying? *Environment Health Perspect, 118*(6), A246–252

Dahllöf, L. (2003). Life cycle assessment (LCA) applied in the textile sector: the usefulness, limitations and methodological problems—A literature review. ESA-Report 2003, Retrieved from https://core.ac.uk/download pdf/70570760.pdf

De Jong, M. D., Harkink, K. M., & Barth, S. (2018). Making green stuff? Effects of corporate greenwashing on consumers. *Journal of Business and Technical Communication, 32*(1), 77–112.

de Jong, M. D., Huluba, G., & Beldad, A. D. (2020). Different shades of greenwashing: Consumers' reactions to environmental lies, half-lies, and organizations taking credit for following legal obligations. *Journal of Business and Technical Communication, 34*(1), 38–76.

Defra. (2008). *Sustainable clothing roadmap briefing note December 2007: Sustainability impacts of clothing and current interventions*. Defra London.

Delmas, M. A., & Burbano, V. C. (2011). The drivers of greenwashing. *California Management Review, 54*(1), 64–87.

Drozdowski, V. (2023). Greenwashing policy briefing in Victoria, AU. Done for Collective Fashion Justice (CFJ) report.

Du, X. (2015). How the market values greenwashing? Evidence from China. *Journal of Business Ethics, 128*(3), 547–574.

Edelman. (2012) Executive Summary: (2012) Edelman Goodpurpose Study. (Report 2012:4) New York: Edelman, Retrieved fromhttps://www.scribd.com/document/90411623/Executive-Summary-2012-Edelman-goodpurpose-Study

Exchange, T. (2010a). Global market report on sustainable textiles.

Exchange, T. (2010b). *Global market report on sustainable textiles: Executive summary*. Textile Exchange.

Falcão, S. M. F., Bezerra, R. A. R., & da Luz, S. G. R. (2020). Concepts and forms of greenwashing: A systematic review. *Environmental Sciences Europe, 32*, 1.

Fletcher, K. (2013). *Sustainable fashion and textiles: Design journeys*. Routledge.

Furlow, N. E. (2010). Greenwashing in the new millennium. *The Journal of Applied Business and Economics, 10*(6), 22.

Gardetti, M. A. (2019). *Introduction and the concept of circular economy, circular economy in textiles and apparel* (pp. 1–11). Elsevier.

Genç, E. (2013). An analytical approach to greenwashing: Certification Versus noncertification. *Journal of Management & Economics, 20*, 2.

Gheibi, M., Karrabi, M., Shakerian, M., & Mirahmadi, M. (2018). Life cycle assessment of concrete production with a focus on air pollutants and the desired risk parameters using genetic algorithm. *Journal of Environmental Health Science and Engineering, 16*, 89–98.

Gleim, M., Smith, J., Andrews, D., & Cronin Jr., J. (2013). Against the Green: A Multi-method Examination of the Barriers to Green Consumption. *Journal of Retailing, 89*(1), 44–61.

Goffetti, G., Böckin, D., Baumann, H., Tillman, A. M., & Zobel, T. (2022). Towards sustainable business models with a novel life cycle assessment method. *Business Strategy and the Environment, 31*(5), 2019–2035.

Gosselt, J. F., van Rompay, T., & Haske, L. (2019). Won't get fooled again: The effects of internal and external CSR ECO-labeling. *Journal of Business Ethics, 155*(2), 413–424.

Guo, R., Tao, L., Li, C. B., & Wang, T. (2017). A path analysis of greenwashing in a trust crisis among Chinese energy companies: The role of brand legitimacy and brand loyalty. *Journal of Business Ethics, 140*(3), 523–536.

Guo, R., Zhang, W., Wang, T., Li, C. B., & Tao, L. (2018). Timely or considered? Brand trust repair strategies and mechanism after greenwashing in China—From a legitimacy perspective. *Industrial Marketing Management, 72*, 127–137.

Hansen, E. G., & Schaltegger, S. (2013). *100 per cent organic? A sustainable entrepreneurship perspective on the diffusion of organic clothing*. Corporate Governance, *13*, 583–98.

Hsu, T. (2011). *Skepticism grows over products touted as eco-friendly* (p. 21). Los Angeles Times.

Husted, B. W., & Allen, D. B. (2009). Strategic corporate social responsibility and value creation. *Management International Review, 49*(6), 781–799.

Inês, A., Diniz, A., & Moreira, A. C. (2023). A review of greenwashing and supply chain management: Challenges ahead. *Cleaner Environmental Systems, 8*, 100136.

Ishimoto, Y., Wulf, C., Schonhoff, A., & Kuckshinrichs, W. (2023). Life cycle costing approaches of fuel cell and hydrogen systems: A literature review. *International Journal of Hydrogen Energy 54*, 361–374.

Jahdi, K. S., & Acikdilli, G. (2009). Marketing communications and corporate social responsibility (CSR): Marriage of convenience or shotgun wedding? *Journal of Business Ethics, 88*(1), 103–113.

Jamali, D., & Karam, C. (2018). Corporate social responsibility in developing countries as an emerging field of study. *International Journal of Management Reviews, 20*(1), 32–61.

Jeswani, H. K., Wehrmeyer, W., & Mulugetta, Y. (2008). How warm is the corporate response to climate change? Evidence from Pakistan and the UK. *Business Strategy and the Environment, 17*(1), 46–60.

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*, 120728.

Johnsson, F., Karlsson, I., Rootzén, J., Ahlbäck, A., & Gustavsson, M. (2020). The framing of a sustainable development goals assessment in decarbonizing the construction industry—Avoiding "greenwashing." *Renewable and Sustainable Energy Reviews, 131*, 110029.

Jönsson, J., Wätthammar, T., & Mark-Herbert, C. (2013). *Consumer perspectives on ethics in garment consumption: Perceptions of purchases and disposal. The ethics of consumption* (pp. 59–63). Springer.

Kalliala, E., & Talvenmaa, P. (2000). Environmental profile of textile wet processing in Finland. *Journal of Cleaner Production, 8*(2), 143–154.

Kane, C. (2001). Environmental and health hazards in spinning industry and their control.

Kim, E.-H., & Lyon, T. P. (2015). Greenwash vs. brownwash: Exaggeration and undue modesty in corporate sustainability disclosure. *Organization Science, 26*(3), 705–723.

King, A. A., & Lenox, M. J. (2000). Industry self-regulation without sanctions: The chemical industry's responsible care program. *Academy of Management Journal, 43*(4), 698–716.

Koszewska, M. (2011). The ecological and ethical consumption development prospects in Poland compared with the Western European countries. *Acta Universitatis Lodziensis. Folia Linguistica, 14*(2), 101–123.

Koszewska, M. (2015). *Life cycle assessment and the environmental and social labels in the textile and clothing industry. Handbook of life cycle assessment (LCA) of textiles and clothing* (pp. 325–344). Elsevier.

Kumar, P. S., & Saravanan, A. (2019). *Sustainable business strategies and circular economy, circular economy in textiles and apparel* (pp. 149–167). Elsevier.

Liu, J., Song, D., Li, Q., Yang, J., Hu, Y., Fang, F., & Joo, Y. H. (2023). Life cycle cost modelling and economic analysis of wind power: A state of art review. *Energy Conversion and Management, 277*, 116628.

Lu, X., Sheng, T., Zhou, X., Shen, C., & Fang, B. (2022). How does young consumers' greenwashing perception impact their green purchase intention in the fast fashion industry? An analysis from the perspective of perceived risk theory. *Sustainability, 14*(20), 13473.

Lyon, T. P., & Maxwell, J. W. (2011). Greenwash: Corporate environmental disclosure under threat of audit. *Journal of Economics & Management Strategy, 20*(1), 3–41.

Lyon, T. P., & Montgomery, A. W. (2015). The means and end of greenwash. *Organization & Environment, 28*(2), 223–249.

MacArthur, E. (2017). *A new textiles economy: Redesigning fashion's future* (pp. 1–150). Ellen MacArthur Foundation.

Majeed, S., & Kim, W. G. (2023). A reflection of greenwashing practices in the hospitality industry: A scoping review. *International Journal of Contemporary Hospitality Management, 35*(3), 1125–1146.

Manickam, P., & Duraisamy, G. (2019). *3Rs and circular economy, circular economy in textiles and apparel* (pp. 77–93). Elsevier.

Marchand, A., & Walker, S. (2008). Product development and responsible consumption: Designing alternatives for sustainable lifestyles. *Journal of Cleaner Production, 16*(11), 1163–1169.

Mikkonen, M. (2016). Increasing green credentials beyond greenwash: Ethical and sustainable standards, organisations and certification in the apparel industry in the 21st century. Retrieved from https://www.theseus.fi/bitstream/handle/10024/104378/Mikkonen_Mila.pdf?sequence=1

Morlet, A., Opsomer, R., Herrmann, S., Balmond, L., Gillet, C., & Fuchs, L. (2017). *A new textiles economy: Redesigning fashion's future*. Ellen MacArthur Foundation, Retrieved from https://www.ellenmacarthurfoundation.org/a-new-textiles-economy

Youngjoo, N., & Dong K. Na., (2015). Investigating the sustainability of the Korean textile and fashion industry. *International Journal of Clothing Science and Technology, 27*, 23–33.

Nguyen, T. T. H., Yang, Z., Nguyen, N., Johnson, L. W., & Cao, T. K. (2019). Greenwash and green purchase intention: The mediating role of green skepticism. *Sustainability, 11*(9), 2653.

Niinimäki, K., Peters, G., Dahlbo, H., Perry, P., Rissanen, T., & Gwilt, A. (2020). Author Correction: The environmental price of fast fashion. *Nature Reviews Earth & Environment, 1*(5), 278–278.

Nisar, Q. A., Haider, S., Ameer, I., Hussain, M. S., Gill, S. S., & Usama, A. (2022). Sustainable supply chain management performance in post COVID-19 era in an emerging economy: A big data perspective. *International Journal of Emerging Markets*, (ahead-of-print).

Notman, N. (2020). Recycling clothing the chemical way. Salisbury (Chemistry World). (Chemistry World). Retrieved from https://www.chemistryworld.com/features/recycling-clothing-the-chemical-way/4010988.article

Nowiński, W., & Rialp, A. (2013). Drivers and strategies of international new ventures from a Central European transition economy. *Journal for East European Management Studies, 8*, 191–231.

Nyilasy, G., Gangadharbatla, H., & Paladino, A. (2014). Perceived greenwashing: The interactive effects of green advertising and corporate environmental performance on consumer reactions. *Journal of Business Ethics, 125*(4), 693–707.

Painter-Morland, M. (2006). Triple bottom-line reporting as social grammar: Integrating corporate social responsibility and corporate codes of conduct. *Business Ethics: A European Review, 15*(4), 352–364.

Paluszek, M., & Thomas, S. (2019). *MATLAB machine learning recipes: A problem-solution approach*. Apress.

Pandey, K. (2018). Fashion industry may use quarter of world's carbon budget by 2050.

Parguel, B., Benoît-Moreau, F., & Larceneux, F. (2011). How sustainability ratings might deter 'greenwashing': A closer look at ethical corporate communication. *Journal of Business Ethics, 102*(1), 15–28.

Pearson, J. (2010). Are we doing the right thing? *Journal of Corporate Citizenship, 37*, 37–40.

Pedersen, E. R. G., & Andersen, K. R. (2023). Greenwashing: A broken business model. *Journal of Business Models, 11*(2), 11–24.
Phifer, M. (2016). The student-athlete's right to organize: How the United States is violating the International Labor Organization Constitution and Declaration of Fundamental Rights. *American University International Law Review, 31*, 475.
Pieczyńska, A., Fiszka Borzyszkowska, A., Ofiarska, A., & Siedlecka, E. M. (2017). Removal of cytostatic drugs by AOPs: A review of applied processes in the context of green technology. *Critical Reviews in Environmental Science and Technology, 47*(14), 1282–1335.
Pizzetti, M., Gatti, L., & Seele, P. (2021). Firms talk, suppliers walk: Analyzing the locus of greenwashing in the blame game and introducing 'vicarious greenwashing.' *Journal of Business Ethics, 170*(1), 21–38.
Plakantonaki, S., Kiskira, K., Zacharopoulos, N., Chronis, I., Coelho, F., Togiani, A., Kalkanis, K., & Priniotakis, G. (2023). A review of sustainability standards and ecolabeling in the textile industry. *Sustainability, 15*(15), 11589.
Pomering, A., & Johnson, L. W. (2009). Constructing a corporate social responsibility reputation using corporate image advertising. *Australasian Marketing Journal, 17*(2), 106–114.
Powell, I., & Prostko-Bell, C. (2010). Leveraging EHS data and tools for a safer and greener supply chain-environmental health and safety (EHS) regulatory compliance programs and strategies, by definition, traditionally have been aimed at preventing violations, fostering safety and reducing risk. *Occupational Hazards, 3*(5), 27.
Pranee, C. (2010). Marketing ethical implication & social responsibility. *International Journal of Organizational Innovation, 2*(3), 6–21.
Qin, Y. (2014). Global fibres overview. In *Proceedings from the asia petrochemical industry conference (APIC)*.
Rajesh, R. (2023). An introduction to grey influence analysis (GINA): Applications to causal modelling in marketing and supply chain research. *Expert Systems with Applications, 212*, 118816.
Ramesh, M., & Rai, N. D. (2017). Trading on conservation: A marine protected area as an ecological fix. *Marine Policy, 82*, 25–31.
Randolph, J. J. (2009). A guide to writing the dissertation literature review. Practical Assessment, *Research and Evaluation, 14*(13), 1–13.
Reddy, B. S., & Ray, B. K. (2011). Understanding industrial energy use: Physical energy intensity changes in Indian manufacturing sector. *Energy Policy, 39*(11), 7234–7243.
Remy, N., Speelman, E., & Swartz, S. (2016). *Style that's sustainable: A new fast-fashion formula*. McKinsey Global Institute.
Romero, P. (2008). Beware of green marketing, warns greenpeace, abs-cbnNEWS.com/Newsbreak
Rostami, R., Khoshnava, S. M., Lamit, H., Streimikiene, D., & Mardani, A. (2017). An overview of Afghanistan's trends toward renewable and sustainable energies. *Renewable and Sustainable Energy Reviews, 76*, 1440–1464.
Roy Choudhury, A. K. (2014). Environmental impacts of the textile industry and its assessment through life cycle assessment. *Roadmap to Sustainable Textiles and Clothing: Environmental and Social Aspects of Textiles and Clothing Supply Chain, 5*, 1–39.
Ruiz-Blanco, S., Romero, S., & Fernandez-Feijoo, B. (2022). Green, blue or black, but washing—What company characteristics determine greenwashing? *Environment, Development and Sustainability, 8*, 1–22.
Sadeghi, B., Marfavi, Y., AliAkbari, R., Kowsari, E., Borbor Ajdari, F., & Ramakrishna, S. (2021). Recent studies on recycled PET fibers: Production and applications: A review. *Materials Circular Economy, 3*(1), 1–18.
Saha, K., Dey, P. K., & Papagiannaki, E. (2021). Implementing circular economy in the textile and clothing industry. *Business Strategy and the Environment, 30*(4), 1497–1530.
Salomone, R. (2023). Fast fashion & greenwashing: The worst combination for sustainability.
Seele, P., & Gatti, L. (2017). Greenwashing revisited: In search of a typology and accusation-based definition incorporating legitimacy strategies. *Business Strategy and the Environment, 26*(2), 239–252.
Seitenwerkstatt, D. (2022). GOTS the leading organic textile standard-GOTS.
Shirvanimoghaddam, K., Motamed, B., Ramakrishna, S., & Naebe, M. (2020). Death by waste: Fashion and textile circular economy case. *Science of the Total Environment, 718*, 137317.
Solomon, J. F., & Edgley, C. R. P. (2008). The abandoned mandatory OFR: A lost opportunity for SER? *Social Responsibility Journal, 4*, 324–348.
Standard, G. O. T. (2008). Global organic textile standard. *Recuperado* el 27. https://www.statista.com/statistics/1268165/market-cap-esg-score-framework-provider-worldwide, https://www.statista.com/statistics/1268534/comparison-esg-scores-largest-companies-provider-worldwide/

Suchman, M. C. (1995). Managing legitimacy: Strategic and institutional approaches. *Academy of Management Review, 20*(3), 571–610.

Sun, Z., & Zhang, W. (2019). Do government regulations prevent greenwashing? An evolutionary game analysis of heterogeneous enterprises. *Journal of Cleaner Production, 231*, 1489–1502.

Sundbotten, K. (2021). *Greenwashing, but make it fashion*. Handelshøyskolen BI. Retrieved from https://biopen.bi.no/bixmlui/bitstream/handle/11250/2827363/2940516%20(1).pdf?sequence=1

Testa, F., Boiral, O., & Iraldo, F. (2018). Internalization of environmental practices and institutional complexity: Can stakeholders pressures encourage greenwashing? *Journal of Business Ethics, 147*(2), 287–307.

Thakker, A. M., & Sun, D. (2023). Sustainable Development goals for textiles and fashion. *Environmental Science and Pollution Research, 30*, 1–21.

Thiry, M. C. (2011). Staying alive: Making textiles sustainable. *AATCC Rev, 11*, 26–32.

Tonti, L. (2022). Fashion brands grapple with greenwashing: 'It's not a human right to say something is sustainable'. *The Guardian*.

UNOPS, A. (2009). Guide to environmental labels-for procurement practitioners of the united nations system. *Unops*, 38.

Uyar, A., Karaman, A. S., & Kilic, M. (2020). Is corporate social responsibility reporting a tool of signaling or greenwashing? Evidence from the worldwide logistics sector. *Journal of Cleaner Production, 253*, 119997.

von Flüe, L., Efferson, C., & Vogt, S. (2024). Green preferences sustain greenwashing: Challenges in the cultural transition to a sustainable future. *Philosophical Transactions of the Royal Society B, 379*(1893), 20220268.

Walker, K., & Wan, F. (2012). The harm of symbolic actions and green-washing: Corporate actions and communications on environmental performance and their financial implications. *Journal of Business Ethics, 109*(2), 227–242.

Walsh, G., Hennig-Thurau, T., & Mitchell, V.-W. (2007). Consumer confusion proneness: Scale development, validation, and application. *Journal of Marketing Management, 23*(7–8), 697–721.

Wang, H., Ma, B., & Bai, R. (2019). The spillover effect of greenwashing behaviours: an experimental approach. *Marketing Intelligence & Planning, 38*, 283–295.

Wang, W., Sun, Z., Zhu, W., Ma, L., Dong, Y., Sun, X., & Wu, F. (2023). How does multi-agent govern corporate greenwashing? A stakeholder engagement perspective from "common" to "collaborative" governance. *Corporate Social Responsibility and Environmental Management, 30*(1), 291–307.

Worley, D. (2020). New textile exchange report shows latest trends in the preferred fiber and materials market—Growth in most areas but not at the speed and scale required.

Yang, Z., Nguyen, T. T. H., Nguyen, H. N., Nguyen, T. T. N., & Cao, T. T. (2020). Greenwashing behaviours: Causes, taxonomy and consequences based on a systematic literature review. *Journal of Business Economics and Management, 21*(5), 1486–1507.

Yildirim, S. (2023). Greenwashing: a rapid escape from sustainability or a slow transition? *LBS Journal of Management & Research*.

Yousaf, A. M., & Aqsa, R. (2023). Integrating circular economy, SBTI, digital LCA, and ESG benchmarks for sustainable textile dyeing: A critical review of industrial textile practices. *Global NEST Journal, 25*, 39–51.

Yu, E.P.-Y., Van Luu, B., & Chen, C. H. (2020). Greenwashing in environmental, social and governance disclosures. *Research in International Business and Finance, 52*, 101192.

Zabaniotou, A., & Andreou, K. (2010). Development of alternative energy sources for GHG emissions reduction in the textile industry by energy recovery from cotton ginning waste. *Journal of Cleaner Production, 18*(8), 784–790.

Zimmer, M. R., Stafford, T. F., & Stafford, M. R. (1994). Green issues: Dimensions of environmental concern. *Journal of Business Research, 30*(1), 63–74.