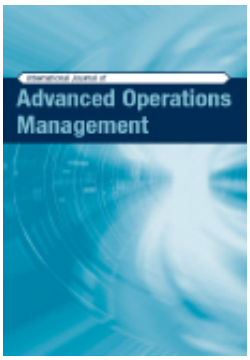

International Journal of Advanced Operations Management

ISSN online: 1758-9398 - ISSN print: 1758-938X
https://www.inderscience.com/ijaom

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DOI: 10.1504/IJAOM.2023.10060875

Article History:

Received:	10 August 2022
Last revised:	08 February 2023
Accepted:	16 October 2023
Published online:	19 August 2024

Sustainability 4.0 in the fashion industry: a systematic literature review

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Abstract: This paper aims to identify the factors that affect Sustainability 4.0 in the fashion industry through a systematic literature review (RSL). To carry out the RSL, the Web of Science and Scopus databases were used, with a time limit between the years 2017 and 2022. The RSL identified 26 papers considered a relevant contribution to the construction of knowledge about the researched topic. From these papers, 46 factors were listed that affect Sustainability 4.0 in the fashion industry, based on the dimensions established by the triple bottom line (TBL) theory, with 19 factors linked to the economic dimension, 12 to the social dimension and 15 to the environmental dimension. The paper concludes that a synergistic relationship was observed between the listed factors and the subject studied. Thus, this article offers a new contribution to the literature, providing data for different audiences, leading them to sustainable and technological development.

Keywords: sustainable development; fashion industry; digital transformation; Industry 4.0; sustainability.

Reference to this paper should be made as follows: da Silva, M.F.V.O.B. and de Melo, F.J.C. (2024) 'Sustainability 4.0 in the fashion industry: a systematic literature review', *Int. J. Advanced Operations Management*, Vol. 15, No. 4, pp.293–323.

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1 Introduction

The concept of Industry 4.0 (I4.0) is linked to the Fourth Industrial Revolution in manufacturing, in which technological solutions such as digitisation, artificial intelligence (AI) and automation are transforming production processes. The trend of this new industrial model is based on how to describe the trend of digitisation and automation of the manufacturing environment (Oesterreich and Teuteberg, 2016; Kumar et al., 2021), or even, according to Amaral (2016), the I4.0, consists of merging production methods with the latest developments in information and communication technology.

From a technical point of view, the concept of I4.0 is defined as a growing trend towards the digitisation of the industry, enabling the creation of pathways that will allow establishing links between companies and their partners, including the emergence of new business models (Oesterreich and Teuteberg, 2016) and among some technologies that incorporate the dynamics of I4.0 are robotics, AI, big data, internet of things (IoT), intelligent algorithms, automation, synthetic biology, cloud computing and cyber physical systems.

Based on these assumptions, negative and positive impacts arise with each new wave of technological revolution and historically the textile industry has been the most powerful factor in accelerating economic growth and the industrial sector has had a great impact on the entire social environment and on various sectors of the economy (Marson, 2014; Ahmmed and Babu, 2022). Concomitantly with the impetus for this digital transformation, there is the need to advance in the implementation of sustainability, so that it is present throughout the entire textile production chain, including its various segments (children's fashion, women's fashion, men's fashion, sportswear, yarns, fabrics, jeanswear, underwear, fabrics for decoration, homewear, among countless others) thus increasing transparency in the processes of the fashion industry.

According to data from the Textile and Apparel Industry Association, in Brazil alone, the textile and apparel industry had an estimated turnover of R$ 194 billion in the year 2021 (ABIT, 2021). Further deepening the prominence of this sector in the Brazilian economic scenario, we bring the Confections Pole of the Agreste of Pernambuco, an agglomeration of productive and commercial initiatives related to the apparel sector. Together, Caruaru, Santa Cruz do Capibaribe and Toritama are the main cities inserted in the Pole. The production of garments made in these three cities is sold all over Brazil and abroad. According to the Economic Study of the Local Productive Arrangement (APL) of Garments of the Pernambuco Agreste, published by the Brazilian Service of Support to Micro and Small Companies (SEBRAE), the gross annual income of the Pole is close to R$1 billion. There are about 20,000 production units that employ 130,000 people in ten cities in Pernambuco (SEBRAE, 2014).

Added to these large numbers, there is the excessive exploitation of natural resources due to industrial growth and the consequent harm caused to the environment in processes that degrade nature, such as pollution and its effects, has generated the need for legal changes and environmental zeal by the main responsible for the problems: the industrial sector (Schulte and Lopes, 2008).

Fashion, while industry, whether in the clothing or apparel segment, represents one of the largest consumers of resources, since it has always been among the most polluting in the world and, this great impact generated is also related to the complexity of the textile chain (Seuring et al., 2004). Among the environmental impacts caused by this production chain we can immediately mention the excessive use and contamination of water and the

growing emission of greenhouse gases, reaching 8% of total emissions in the world in 2016 (UNEP, 2020).

According to Santos (1997), in all processes of the textile and apparel production chain, waste is generated, whether chemical or not. Since the process of making the fabric in the industry, in the knitting stage, for example, solid waste is generated from the fabric fibres, fibre tips, which may be considered useless for the production in question, and thus discarded.

In addition, the short life cycle of textile and clothing products, an obsolescence often already programmed by 'fast-fashion' production, is another critical point that challenges the multitude of sustainability aspects in this industry (Kaikobad et al., 2015; McNeill and Moore, 2015). 'End-of-life' textiles are very complex to deal with after disposal even by the range of different fibres included, the different industrial processes performed (including dyeing processes) and the huge range of different clothing accessories such as: buttons, zippers, metal items, labels, among others (Marques et al., 2020).

To associate fashion to sustainability is to associate the textile industry and fashion consumption to sustainable development (Berlin, 2014). The perception of sustainable development, in turn, had been redesigned, starting to be influenced by what would be the three dimensions of sustainability: economic, social and environmental. According to the theory, called triple bottom line (TBL), such dimensions, besides influencing, reinforce each other, suggesting that organisations should consider social and environmental performance, not just financial performance, in their business operations (Shen et al., 2012), seeking a harmonic coexistence between economic viability, the environment and society (Lüdeke-Freund, 2010).

It is worth mentioning that companies with a good performance in the environmental, social and corporate governance (ESG) agenda are better prepared to face the challenges that continually arise. They invest in sustainability as an added value, for example tracking their entire production chain (including outsourced workers) to ensure compliance with legislation and the dilution of socio-environmental impacts associated with their brand. The indices that show true sustainability within organisations are increasingly valued and discussed in the corporate environment, even gaining importance on the world's stock exchanges, making the actions of sustainable organisations more profitable than organisations not so concerned with this issue, which it has already gone from relevant to essential (Costa and Ferezin, 2021; Al-Odeh et al., 2021).

Based on this discussion, it is necessary to understand the factors that affect sustainability based on the processes of I4.0 in the Fashion Industry. Thus, this paper aims to identify the factors that affect Sustainability 4.0, linking them to the three dimensions established by the TBL in the fashion industry through a systematic literature review (SLR). It is worth noting that this article understands Sustainability 4.0 as a new mindset for sustainable development, which is based on the positive correlation between the so-called I4.0 technologies and the three dimensions established by the TBL, thus promoting the viability of offering sustainable solutions to more diverse chains of productive sectors.

Following global trends, just like other manufacturing sectors, the textile and apparel industry is also going through its digitalisation process (Behr, 2018). Thus, this study contributes to enhance efforts to promote the adoption of sustainable production practices within textile manufacturing, in addition to highlighting a new look at social, industrial, and technological development. In addition, this study brings a broad perspective through

insights based on trends, providing data for different audiences, which can effectively contribute to a positive transition of the Fashion Industry towards the implementation of I4.0 and the development of industrial and technological models., be it for scholars and academics, entrepreneurs, managers, various professionals, collaborators, policy makers and society as a whole, which is increasingly complex, plural, critical, conscious and increasingly focused on the digital age.

This paper was structured in sections, organised as follows: Section 2 is the theoretical foundation, providing background on theoretical and contextual aspects related to the research. Section 3 presents the SLR methodology, detailing the steps taken to identify, select, and analyse the relevant studies. Section 4 presents the results, analysed from the descriptive and narrative perspectives, and finally, Section 5, with the conclusions, limitations, and future implications of this literature review.

2 Theoretical background

2.1 The impact of the textile industry on sustainability

The management of sustainability in the operations of the fashion industry is a field of growing concern, after all, textile and clothing manufacturing is one of the most wasteful consumer industries in the world, representing one of the largest consumers of resources, since it has always been among the most polluting, generating waste throughout its production chain. In addition, the short life cycle of textile and clothing products meets the multiplicity of sustainability scenarios in the context of this industry. Added to this planetary imposition is society's increased awareness and concern about unsustainable production and consumption (Nery, 2019).

Studies by the Ellen MacArthur Foundation (2017b) point out that less than 1% of all clothes in circulation are recycled back into clothes, and among the main challenges for this are technological barriers, such as the lack of waste separation technologies mixed textile fibres (Sandin and Peters, 2018).

According to Viana et al. (2008), the Brazilian clothing sector produces 7.2 billion pieces of clothing per year, being the 2nd largest producer of indigo in the world; the 3rd largest knitwear producer; the 5th largest clothing producer; the 7th largest world producer of yarns and filaments and the 8th world producer of fabrics. Thus, the textile and clothing industry is one of the most important sectors of the national economy, both in terms of job creation and the value of its production. As a result of this production, it is also estimated that in Brazil alone, around 170,000 tons of scraps are generated per year, that is, fabric leftovers and discards end up in landfills or are incinerated, while only 20% are recycled (SEBRAE, 2014). In 2017, Brazil was the 10th largest textile producer in the world, with production of approximately 2 million tons, equivalent to US$13 billion (Mendes, 2017).

Textile waste increased by 811% between 1960 and 2015, according to research conducted by the USEPA (2021). As reported, EPA data estimates that the amount of this waste grew from 1.76 million tons in 1960 to 16 million tons in 2015. In addition, the amount of textiles that ended up in landfills also saw a sharp increase, from 1.71 million tons in 1960 to 10.5 million tons in 2015, which is equivalent to 66% of textile waste. Thus, one can see that this waste represents a large portion of the contributing elements to environmental pollution in Brazil and worldwide (USEPA, 2021).

The current extract-transform-discard model of the fashion industry has been perceived as the source of environmental problems and economic value losses for this sector (Niinimäki et al., 2020). For example, annually in the European Union, it is speculated that 5.8 million tons of textile resources are discarded, of which only 1.5 million go through some recycling process, so the remaining 4.3 million are landfilled or incinerated (Trajkovic et al., 2017). An estimated $400 billion in value is lost every year due to clothing being underused and rarely recycled (Shirvanimoghaddam et al., 2020). Based on studies and documents prepared by the Ellen MacArthur Foundation (2017a), if nothing changes, by 2050, the fashion industry will have spent a quarter of the world's carbon budget. In addition, washing clothes, which uses exorbitant gallons of water, releases half a million tons of plastic microfibres into the ocean every year, equivalent to more than 50 billion plastic bottles.

To broaden the reflection on the issue, we rescued the thought of Fletcher and Grose (2011, p.13) to expand when they say that:

> "The material used in the manufacture of clothing is associated with all kinds of sustainability impacts: climate change; adverse effects on water and its cycles; chemical pollution; loss of biodiversity, excessive or inappropriate use of non-renewable resources, waste generation; effects negative effects on human health; and harmful social effects for the producing communities."

Still regarding this issue, Piribauer and Bartl (2019) add that there is an expectation that fibre production will result in the amount of 100 million tons per year in the coming years, which only highlights the imminence of more serious environmental problems, since the useful life of clothing products is decreasing and that such production levels are not sustainable according to the availability of resources present on the planet. The authors strongly advocate the need for the population to rethink their consumption habits.

As stated by Marques et al. (2020), a transition model to sustainability is required which, in turn, according to Barbosa (2008), consists in finding means of production, distribution and consumption of existing resources in a more cohesive, economically efficient and ecologically viable manner. That said, acting with a focus on sustainability as an ignition for the renewal and longevity of the industry is fundamental.

This scenario has been demanding a structural transformation of the textile industry towards not only sustainable production and consumption systems, with less impact on environmental aspects, but also capable of collaborating for the socioeconomic development of society in a horizontal way (Modefica et al., 2020).

In this sense, digital transformation goes far beyond the intensive use of information and communication technologies. The adoption of new technologies is an opportunity for competitive gain. This is even seen in cases of companies that innovate in technologies capable of making better use of materials, recycling or even creating value networks and/or new business models. In addition, considering how competitive the fashion industry is, where new companies emerge daily, the advantage of adopting new, more efficient and sustainable technologies can mean cost reductions and market gains.

2.2 Industry 4.0

In summary, the concept of I4.0, also entitled 'Fourth Industrial Revolution' happened after three historical transformative processes and is the result of the progressive integration of digitalisation to the industrial activity (Albertin and Pontes, 2021). The

term I4.0 was first used in 2013, during an industrial technology fair, known as Hannover Fair, in Germany, from strategic initiatives of the German government to consolidate the country as a technological leader, strengthening its globais competitiveness (Kagermann et al., 2013). Transformative historical processes are the result of the progressive integration of digitalisation to the industrial activity (Albertin and Pontes, 2021). The term I4.0 was first used in 2013, during an industrial technology fair, known as the Hannover Fair, in Germany, from strategic initiatives of the German government to consolidate the country as a technological leader, strengthening its globais competitiveness (Kagermann et al., 2013).

Therefore, the so-called 'Fourth Industrial Revolution' has been described as a production model where new production models will intensely transform all major industrial systems, and it has also been targeted in many government plans as a goal for a sustainable future (Bertola and Teunissen, 2018).

Bocken et al. (2014) defined sustainable business model (SBM) as one that creates significant positive and/or negative impacts for the environment and/or society through changes in the way the organisation and its value networks create, deliver and capture value or change its value proposition. Furthermore, just as stated by Marques et al. (2020) corporate social responsibility within companies can be integrated with the new challenges and opportunities assessed by I4.0, responding to the environmental, economic and social requirements for a sustainable business. Bringing the reference of this concept to the clothing industry context, we can frame companies that bring in their agendas and processes, practices related mainly to lower impact production, efficient design, optimised service life, new fashion systems and, conscious consumption (Berlim, 2020).

According to Yin et al. (2018), I4.0 consists of a technological revolution that offers society the opportunity for a fundamental transition, not only shaping the design of new technologies, but also providing agile forms of governance and positive values transforming the way we live, work, and relate.

This fourth change brings with it a trend towards total factory automation, so the I4.0 transformation movement is revolutionising the way companies manufacture, improve, and distribute their products (Oláh et al., 2020). Enabling and empowering technologies are increasingly being integrated into the operational sectors and strategic thinking of organisations, raising the production bar.

Among the main technologies responsible for the configuration of I4.0 are: the IoT, cloud computing, integrated systems, simulations, big data, autonomous robots, augmented reality (AR) and additive manufacturing/3D printing (Albertin and Pontes, 2021). Besides these, Javaid et al. (2022) mention: machine learning, machine vision, data analytics and additive manufacturing.

In this context, it is possible to identify several I4.0 articles that address the theme of sustainability (e.g., Ghobakhloo, 2020; Luthra and Mangla, 2018; Bai et al., 2020; Bonilla et al., 2018; Gabriel and Pessl, 2016), but of the existing articles, the theme of 'Sustainability 4.0' is little explored, being a gap in the current literature.

Since the concepts of I4.0 and Sustainability are directly related and a clear concept of Sustainability 4.0 was not identified in the literature, this article sought to conceptualise Sustainability 4.0 as a new mindset of sustainable development, which is based on the positive correlation between the so-called I4.0 technologies (robotics, AI, big data, IoT, intelligent algorithms, automation, synthetic biology, cloud computing and cyber-physical systems) and the three dimensions established by the TBL (economic,

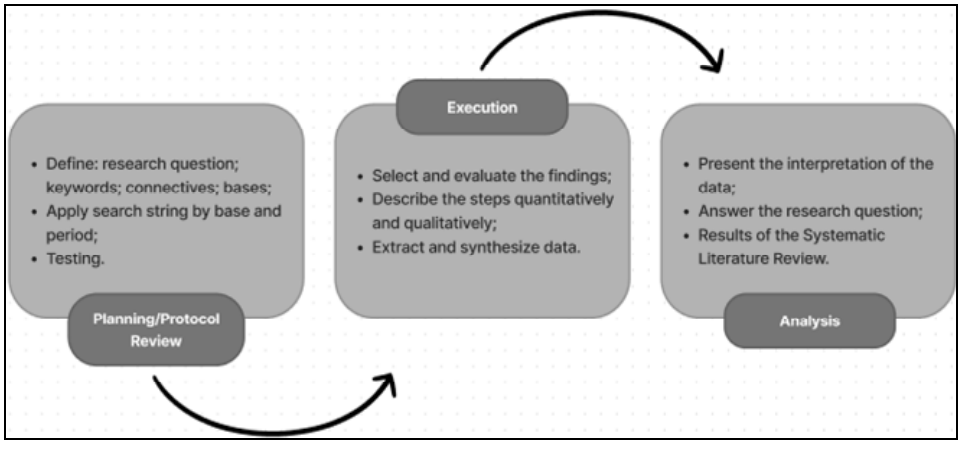
social and environmental), thus promoting the viability of offering sustainable solutions to the most diverse chains of productive sectors.

Sustainability 4.0 is being enabled through the effective adoption of modern technologies that enable services at significantly lower prices due to the effective use of energy and resources with less waste (Javaid et al., 2022). For Gomes et al. (2022) with the practice of sustainability arising from I4.0, organisations have improved the efficiency of their production processes, making more assertive forecasts and managing to minimise environmental impacts.

3 Methodology

This section discusses how the adopted methodology will be developed – SLR which, as postulated by Hulley et al. (2015), uses an approach that occurs through the selection of primary studies under uniformly applied criteria, aiming to identify the productions considered relevant, demonstrating the characteristics and results of eligible studies. According to Kitchenham and Charters (2007), an SLR involves three main phases: planning, execution, and analysis/reporting of the study synthesising the relevant results, as presented in Figure 1. The SLR also enables the identification of clusters of evidence, as well as their absence for the purpose of directing future efforts and pointing to new areas of primary studies.

Figure 1 Stages of SLR



Source: The authors (2022)

In the planning stage, the keywords, the research question and, finally, the academic databases that would be consulted were defined. The intention of the word selection process was to reach a significant number of relevant works related to the theme, and then test combinations were performed to verify the primary results, which were concatenated in the schematic structure presented in Table 1.

Thus, the execution of the searches in the academic databases followed the search strings detailed in Table 2.

Table 1 Scheme of keyword

Description of titles	*Connectives and/or*	*Description of topics*
Fashion industry	And	Sustainable development
Fashion industry	And	Digital transformation
Fashion industry	And	Industry 4.0
Fashion industry	And	Sustainability

Source: The authors (2022)

Table 2 String scheme per database

Database	*Strings*
WOS – Web of Science	Sustainable development (all fields) and fashion industry (all fields) or digital transformation (all fields) and fashion industry (all fields) or Industry 4.0 (all fields) and fashion industry (all fields) or sustainability (all fields) and fashion industry (all fields) and open access and 2017 or 2018 or 2019 or 2020 or 2021 or 2022 (years of publication) and all open access (open access) and English (languages) and environmental sciences or green sustainable science technology or environmental studies or business or management (categories in the Web of Science)
Scopus	(TITLE-ABS-KEY (sustainable AND development) AND TITLE-ABS-KEY (industry) OR TITLE-ABS-KEY (digital AND transformation) AND TITLE-ABS-KEY (fashion AND industry) OR TITLE-ABS-KEY (Industry 4.0) AND TITLE-ABS-KEY (fashion AND industry) OR TITLE-ABS-KEY (sustainability) AND TITLE-ABS-KEY (fashion AND industry)) AND (LIMIT-TO (OA, "all")) AND (LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017)) AND (LIMIT-TO (SUBJAREA, "BUSI") OR LIMIT-TO (SUBJAREA, "ENVI")) AND (LIMIT-TO (LANGUAGE, "English"))

Source: The authors (2022)

The Web of Science – main collection (Clarivate Analytics) and Scopus databases were consulted, with a time frame of publications between 2017 and 2022 in order to capture the latest research in the area, after the World Economic Forum in 2016. In detail, the selections of inclusion and exclusion criteria are listed in Table 3.

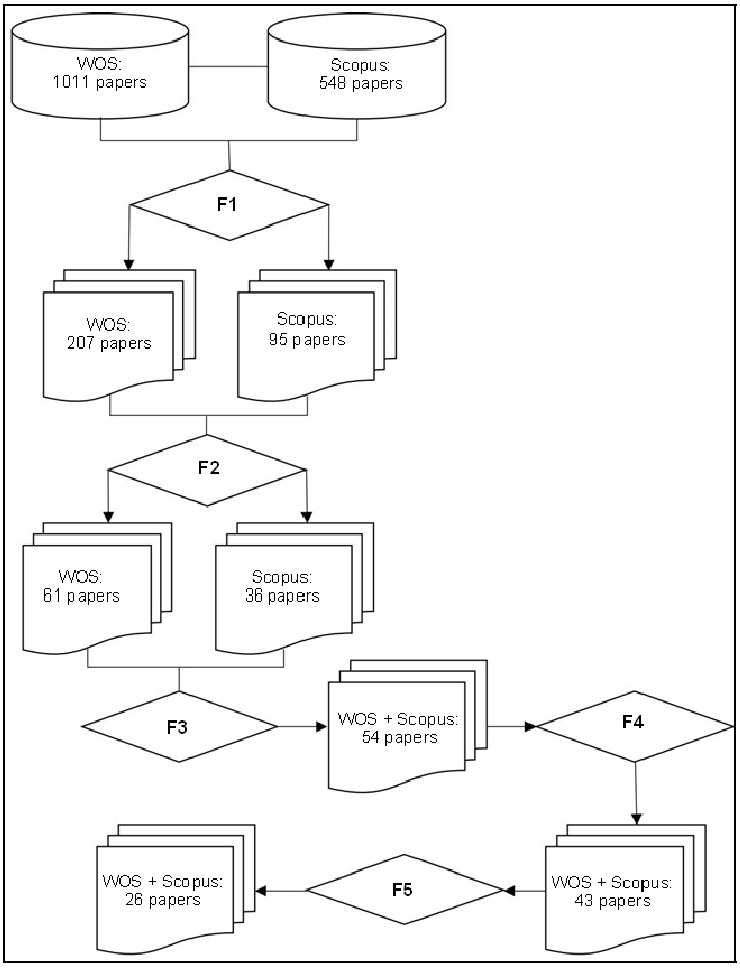
After conducting the word search, even without applying any exclusion filter, the articles located totalled 1,559, 1,011 documents listed on the Web of Science and 548 listed on Scopus. Then, the phase called phase 1 (F1) began, which consisted of excluding documents, disregarding all articles that did not fit into the knowledge areas delimited in CI1, and applying the temporal exclusion criterion, disregarding all works prior to 2017, according to CI2, and also disregarding publications in languages other than English. In addition, articles that did not provide open access to the full content were not considered. This resulted in 302 articles (207 in WOS and 95 in Scopus) still considered relevant. Subsequently, the phase entitled, phase 2 (F2), analysis of the titles of the articles was performed, and 97 documents were selected (61 in WOS and 36 in Scopus). Then, in the call, phase 3 (F3), analysis of the abstracts, the number of remaining relevant items was 54 documents (32 in WOS and 22 in Scopus).

Table 3 Inclusion and exclusion criteria

ID	*Inclusion criteria*	*ID*	*Exclusion criteria*
CI1	Papers in the areas: environmental sciences, business, management and accounting; environmental sciences; green sustainable science technology; environmental studies	CE1	Articles with titles or abstracts with scope outside this research
CI2	Articles published in time frame between 2017 and 2022	CE2	Duplicate articles
CI3	Articles written in English languages	CE3	Articles with full text not available for access
CI4	Articles with open access available to their full texts	CE4	Full-text articles with scope outside this research

Source: The authors (2022)

Figure 2 Filtering process



Source: The authors (2022)

With the application of CE3, the articles that were repeated were discarded in phase 4 (F4), and the number of documents was reduced to 43 (25 in WOS and 18 in Scopus). Finally, after reading the texts in full, the last exclusion criterion, CE4, the result was 26 articles considered valid for the research theme, ending in phase 5 (FP5) the filtering process outlined in Figure 2.

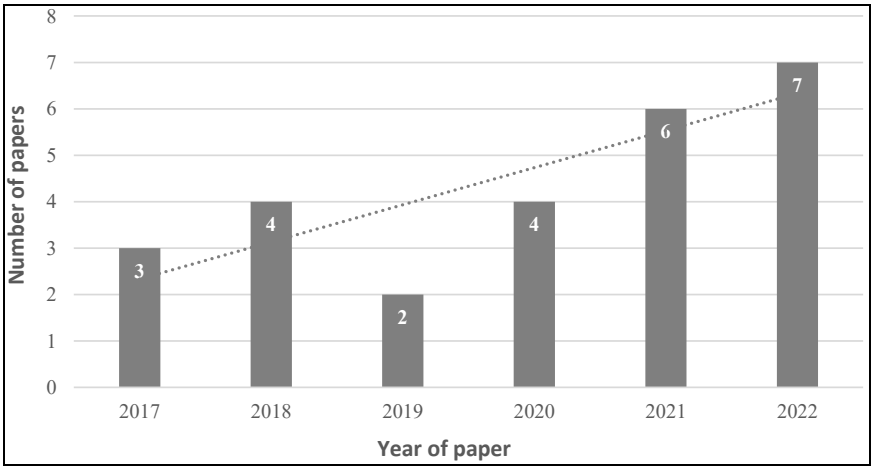
4 Results

Moving on to the last phase of the SLR, some analyses were performed on the 26 selected articles from descriptive and narrative perspectives.

4.1 Descriptive analysis

The 26 selected papers against the research topic in the period from 2017 to 2022 are listed descriptively. Figure 3 presents the selected papers by year of publication. It can be seen that studies related to the factors that affect Sustainability 4.0 in the fashion industry have been growing over the past six years, observing from the year 2020 a significant increase in the volume of publications. In the first three years of the analysis (2017, 2018 and 2019), the number of publications were three, four and two articles, respectively, totalling nine published articles. In the following three years (2020, 2021 and 2022), there were 17 published articles, representing an 88% increase in the volume of publications, as shown in Figure 3.

Figure 3 Articles published per year

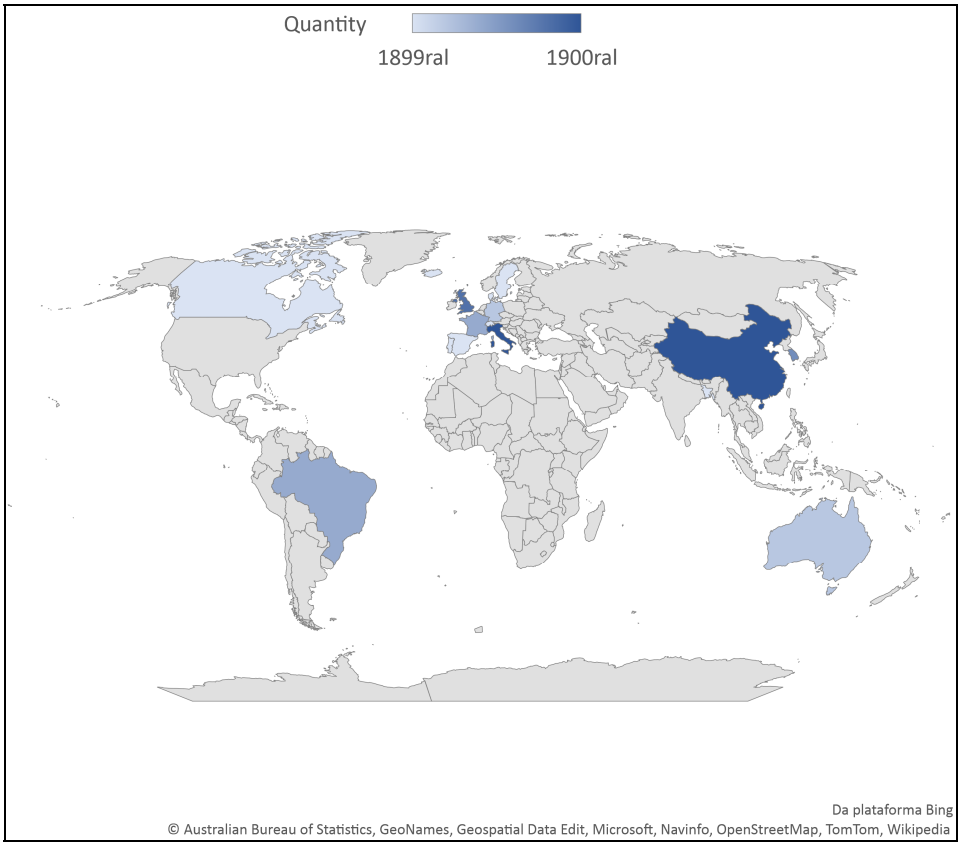


Source: The authors (2022)

Figure 4 shows the world map, highlighting the nationalities of the authors of the analysed articles in order to delineate in a macro view, where and to where the theme studies are adherent. It is noticeable that there is a continuous growth in research related to the theme. Four continents had author representatives involved (USA, Europe, Asia and Oceania) in the studies selected in the RSL. The countries with the largest number of authors related to the research scope are Italy and China, with six representatives,

followed by the UK and South Korea, with five and four authors, respectively. Next, France and Brazil, come with three authors each. Australia and Germany, in turn, have two authors each. The remaining countries have one author each, as listed: Spain, Portugal, Canada, Bangladesh, Denmark, Switzerland, Singapore, Sweden, and Iceland.

Figure 4 Map of published articles by nationality of authors (see online version for colours)



Source: The authors (2022)

Through the online platform Wordclouds it was performed, considering the two databases used in the research, Web of Science and Scopus, an analysis related to the keywords of all 26 articles object of this systematic review, thus creating the visual representation of a network of main keywords in which it was observed that 15 of them received greater prominence due to their appearance with greater frequency. They were: fashion, industry, management, design, sustainability, innovation, circular, supply, chain, production, apparel, technology, textile, business and sustainable. Figure 5 illustrates the representation obtained.

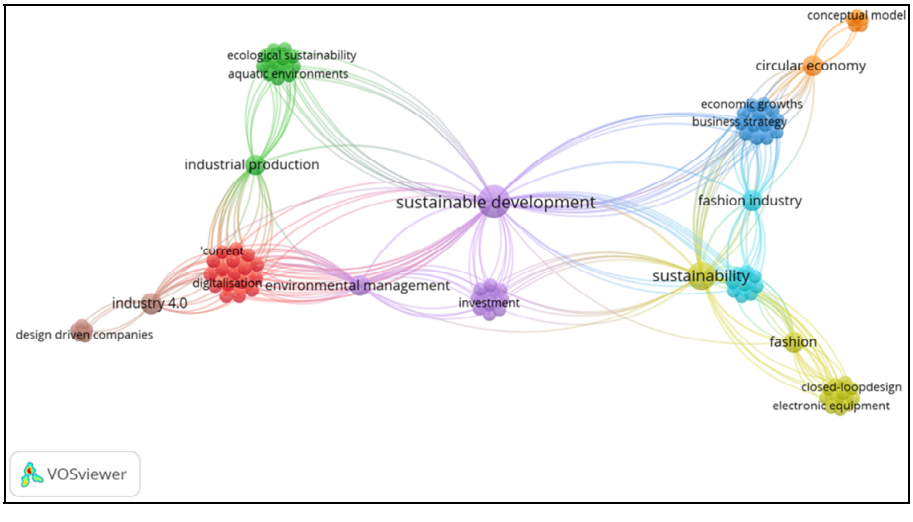
An analysis was also performed relating the keywords of the articles in the VOSviewer software using the files of the two databases used from the RSL (Web of Science and Scopus) that contained the 26 articles selected as relevant to the research. A co-occurrence network had been created with two interactions between the keywords the databases identified as strongly present. Eight main clusters were formed, where the size

and colour of the circle illustrate the frequency of occurrence of the individual keyword and the type of cluster as respectively illustrated in Figure 6.

Figure 5 Keyword cloud for articles

Source: The authors (2022)

Figure 6 Keyword co-occurrence network with two interactions (see online version for colours)



Source: The authors (2022)

Table 4 Descriptive data

Year	*Title*	*Author*	*Country*	*Keywords*	*Paper type*	*Editorial areas*
2017	Innovative and sustainable business models in the fashion industry: entrepreneurial drivers, opportunities, and challenges	Todeschini, B.V., Cortimiglia, M.N., Callegaro-de-Menezes, D. and Ghezzi, A.	Brazil and Italy	Business model innovation; sustainable fashion; born-sustainable start-ups; social value creation; slow fashion; upcycling	Journal	Business and economics
2017	Seven steps manufacturers must take to begin offering mass customization to their customers	Bellemare, J. and Carrier, S.	Canada	Sustainable mass customisation; digital age; apparel industry; innovation; personalisation; technologies	Conference	Business management and accounting
2017	Sustainability issues in textile and apparel supply chains	Shen, B., Li, Q., Dong, C. and Perry, P.	UK and China	Textile and apparel industry; sustainable supply chain management; sustainable fashion; sustainability	Journal	Environmental science
2018	A collaborative cloud service platform for realizing sustainable make-to-order apparel supply chain	Ma, K., Wang, L.C. and Chen, Y.	China, France and Sweden	Supply chain collaboration; sustainable supply chain; make-to-order; apparel industry; agent-based simulation; optimisation	Journal	Science and technology – other topics; and environmental sciences and ecology
2018	Blockchain enhanced emission trading frame working fashion apparel manufacturing industry	Fu, B.L., Shu, Z. and Liu, X.G.	China	Blockchain; sustainability; fashion apparel industry; carbon trading; energy economics; Industry 4.0	Journal	Science and technology – other topics; and environmental sciences and ecology
2018	Designing a roadmap towards a sustainable supply chain: a focus on the fashion industry	Moretto, A., Macchion, L., Lion, A., Caniato, F., Danese P. and Vinelli, A.	Italy	Sustainability; supply chain; roadmap; fashion luxury; CSR	Journal	Environmental science, business management and accounting
2018	Fashion 4.0. Innovating fashion industry through digital transformation	Bertola, P. and Teunissen, J.	UK and Italy	Industry 4.0; digital transformation; design driven companies; fashion business models; fashion design processes; fashion innovation	Journal	Business management and accounting
2019	Sustainable improvements for customized platform effectiveness in garment production	Ji, Y., Jiang, G. and Cong, H	China	Customised platform; garment virtual design; personal customisation; sustainable production	Journal	Business management and accounting
2019	Sustainability within fashion business models: a systematic literature review	Thorisdottir, T.S. and Johannsdottir, L.	Iceland	Business model; fashion; sustainability; measure; driver; report	Journal	Science and technology – other topics; and environmental sciences and ecology

Source: The authors (2022)

Table 4 Descriptive data (continued)

Year	*Title*	*Author*	*Country*	*Keywords*	*Paper type*	*Editorial areas*
2020	Homo sustentabilis: circular economy and new business models in fashion industry	Marques, A.D., Marques, A. and Ferreira, F.	Portugal	Homo sustentabilis; sustainability; circular economy; fashion industry	Journal	Environmental science
2020	Sustainability in fashion brands	Pero, M., Arrigo, E. and Fionda-Douglas, A.	Italy and UK	Sustainability; fashion; brand management	Journal	Science and technology – other topics; and environmental sciences and ecology
2020	Sustainable solutions for wearable technologies: mapping the product development life cycle	Gurova, O., Merritt, T.R., Papachristos, E. and Vaajakari, J.	Denmark	Sustainability; wearable technology; design; fashion; ICT; closed-loop design; design implications	Journal	Environmental science
2020	Traceability of ready-to-wear clothing through blockchain technology	Bullón Perez, J.J., Queiruga-Dios, A., Martinez, V.G. and del Rey, A.M.	Spain	Blockchain; traceability; textile and clothing industry; ready-to-wear clothing; supply chain	Journal	Science and technology – other topics; and environmental sciences and ecology
2021	Closing the loop on take, make, waste: investigating circular economy practices in the Swedish fashion industry	Brydges, T.	Sweden	Circular economy; fashion; Sweden; sustainability	Journal	Science and technology – other topics; and environmental sciences and ecology
2021	Enhancing the sneakers shopping experience through virtual fitting using augmented reality	Rhee, H.L. and Lee, K.H.	South Korea	Sneakers shopping; augmented reality; virtual fitting; omnichannel; brand advocacy; product involvement	Journal	Science and technology – other topics; and environmental
2021	Managerial and industry 4.0solutions for fashion supply chains	Braglia, M., Marrazzini, L., Padellini, L. and Rinaldi, R.	Italy	Supply chain management; five-whys analysis; Industry 4.0; fashion industry; luxury industry; planning and scheduling	Journal	Business and economics
2021	Semantic network analysis to explore the concept of sustainability in the apparel and textile industry	Youn, C. and Jung, H.J.	South Korea	Sustainability; apparel and textiles; semantic network analysis; social media; big data; text mining	Journal	Science and technology – other topics; and environmental sciences and ecology
2021	Technological and non-technological trends in fashion eco-innovations	MacLennan, M.L.F., Tiago, E.F. and Pereira, C.E.C.	Brazil	Green innovation; GRI fashion industry; technological trends	Journal	Business management and accounting

Source: The authors (2022)

Table 4 Descriptive data (continued)

Year	*Title*	*Author*	*Country*	*Keywords*	*Paper type*	*Editorial areas*
2021	Transformation of the innovative and sustainable supply chain with upcoming real-time fashion systems	Lee, Y.K.	South Korea	Real-time fashion system; personalisation; supply chain; AI; ICT	Journal	Science and technology – other topics; and environmental sciences and ecology
2022	Bio-based innovation as a fashion and textile design must: a European perspective	D'Itria, E. and Colombi, C.	Italy	Fashion design for sustainability; circular materials; bio-based textiles; textile industry; transformation	Journal	Science and technology – other topics; and environmental sciences and ecology
2022	Can digital technologies increase consumer acceptance of circular business models? The case of second hand fashion	Charnley, F., Knecht, F., Muenkel, H., Pletosu, D., Rickard, V., Sambonet, C., Schneider, M. and Zhang, C.L.	UK, Switzerland, Singapore, France and Germany	Sustainability; fashion; circular economy; consumers; digitisation; technology; second hand; resale; reuse; engagement	Journal	Science and technology – other topics; and environmental sciences and ecology
2022	Fast fashion for 2030: using the pattern of the Sustainable Development Goals (SDGs) to cut a more gender-just fashion sector	Vijeyarasa, R. and Liu, M.	Australia	Garment sector; gender justice; migrant workers; Sustainable Development Goals; SDGs; sustainable fashion	Journal	Business and economics; and government and law
2022	Impact of Industry 4.0 on corporate environmental sustainability: comparing practitioners' perceptions from China, Brazil and Germany	Beier, G., Matthess, M., Guan, T., Grudzien, D.I.D.O.P., Xue, B., Lima, E.P.D. and Chen, L.	China, Brazil and Germany	Industry 4.0; corporate sustainability; digitalisation; resource efficiency; environmental management	Journal	Environmental science
2022	Technology-based strategies for online second hand platforms promoting sustainable retailing	Bae, Y., Choi, J., Gantumur, M. and Kim, N.	South Korea	Second hand platform; resale market; e-commerce; technology acceptance model; sustain-ability	Journal	Science and technology – other topics; and environmental sciences and ecology
2022	Textile-apparel manufacturing and material waste management in the circular economy: a conceptual model to achieve sustainable development goal (SDG) 12 for Bangladesh	Khairul Akter, M.M., Haq, U.N., Islam, M.M. and Uddin, M.A.	UK and Bangladesh	Material waste; textile-apparel manufacturing; conceptual model; circular economy; value stream mapping; SDG 12	Journal	Environmental science
2022	The status quo and prospect of sustainable development of smart clothing	Li, Q., Xue, Z.B., Wu, Y.H. and Zeng, X.Y.	China and France	Smart clothing; sustainability; design; production; supply chain	Journal	Science and technology – other topics; and environmental sciences and ecology

Source: The authors (2022)

Cluster 1, purple, contains the following words: sustainable development, environmental management and investment. Cluster 2, yellow, contains the following words: sustainability, fashion, electronic equipment and closed-loop. Cluster 3, green, contains the following words: industrial production, ecological sustainability and aquatic environment. Cluster 4, sky blue, contains the word: mod industry. Cluster 5, turquoise blue, contains the following words: business strategy and economic growths. Cluster 6, orange, contains the following words: circular economy and conceptual model. Cluster 7, red, contains the following words: digitalisation and current. Finally, cluster 8, pink, contains the following words: I4.0 and design firms.

Finishing the descriptive analysis, Table 4 condenses the details of the studies selected for the RSL composition, bringing the following data: year of publication, article title, authors, authors' countries of origin, keywords, type of article, and editorial areas of the article, which enabled several more detailed analyses.

The articles included in the RSL are distributed between international journals and conference, with 25 published in journals, which is equivalent to almost 96.3% of the sample. As for the areas of publication, the ones that appear most often are, in this order: environmental sciences, science and technology; business and economics; and business, management and accountings.

4.2 Narrative analysis

After the structural detailing of the 26 selected works, it was done a brief narration about the main ideas involved in the studies. Todeschini et al. (2017) adduce five socioeconomic and cultural characteristics that drive the business models of the fashion area to mobilise to insert in the context of sustainable development, being the main one the consumer's tendency to be more conscious about their habits. The other aspects highlighted by the authors are the circular economy, shared and collaborative economy, social responsibility of the organisation, collaborative consumption and technological innovation.

Bellemare and Carrier (2017) pointed in their article to what would be the seven steps that the manufacturing industry should follow in order to offer mass customisation to its customers, based on the use of technologies. When it comes to the clothing production/ fashion industry, they exemplify experiences of AR and virtual fitting rooms, which promote a direct movement in consumer participation and collaboration, after all when it comes to this market segment, which is very globalised, the search for 'uniqueness' is the focus. They also go through the concepts of mass markets, product configuration and design, and mass individualism. They conclude that the findings of the study call attention to the need to adapt to the new market/consumer profile and should encourage the players involved in the industry to adopt new mindsets and tools that make the most of information technology aiming at a successful implementation of mass customisation of production.

Shen et al. (2017) argue that, due to the waste of materials and the environmental impacts caused by textile and apparel companies, considering that, globally speaking, they constitute one of the most polluting industries, they were intensely affected by the need to incorporate sustainability guidelines. The authors ratify that this incorporation adds value to the product and to the customer, highlighting a trend of consumers with greater socio-environmental awareness being willing to pay more for a more sustainably produced garment, because they perceive immense added value in these products.

Moreover, they highlight the concern of companies to develop a tripartite approach, i.e., with economic, social, and environmental scopes, based on the TBL.

Ma et al. (2018) show that a collaborative platform can boost the functioning of the clothing supply chain from a sustainable perspective, providing consumers with the possibility of ordering clothing products whose design is customised and personalised, which directs the production according to the demands of the clientele and avoids, in addition to the typical risks of production based on forecasts, greater environmental impacts, which are characteristic of the traditional model of textile production. This new model allows that, based on orders, suppliers are selected to meet the demand, which is characterised as an important boost to the development of sustainable fashion.

Knowing that the fashion industry has been quite highlighted for its damage to the environment, Fu et al. (2018) also studied about the recent blockchain technology, demonstrating the possibility of bringing carbon emission data to society as a means of transparency and encouragement to reduce it in clothing manufactures. In their proposal, the authors mention that carbon emissions are observed in issues such as supply, energy, labour, and waste throughout different stages of textile production.

Moretto et al. (2018) advocate the relevance of structuring a roadmap under a long-term perspective for sustainable practices to be implemented by the management of organisations active in the fashion industry, not only in their internal processes, but throughout the production scope, extending this vision throughout the supply chain, given that "sustainability has become crucial to supply chain strategy, especially in sensitive sectors such as the fashion industry" (Smith, 2003; Li et al., 2016; apud Moretto et al., 2018).

Not only because of the critical environmental problems associated with it, such as intense pollution, animal abuse, high water consumption, and the precarious labour conditions of many of the workers who perform their labour in this productive sector. In order to design an appropriate sustainable path within companies, they argue, the roadmap should identify practices and steps to guide a sustainable transformation for organisations, aimed at operational and strategic guidelines towards the establishment of sustainable production and consumption patterns. The extension of the focus on sustainability capability to the supply chain, aims at greater efficiency of production processes, such as better waste and resource management.

Bertola and Teunissen (2018) highlight I4.0 as a promising path to achieve sustainability in the textile and apparel industry, since companies have sought to link technological development to the both efficiency in the production process and consumer satisfaction. An example of this are some sportswear brands, which have sought to develop more resistant fibres and invested in thermal protection technologies and the like. In addition, the authors emphasised the connection of customers with today's values, so that they seek proposals that present customisation, co-creation, and sustainable patterns. Thus, as new production and consumption modes are potentiated in the fashion market, design and customers occupy the centrality of the fashion environment and interests.

Ji et al. (2019) sought to conduct a study in China's apparel industry, aiming to ascertain the effectiveness of a personalised platform in fashion design and production, grounded by big data technology through the use of apparel CEO-design (CED) and apparel life cycle assessment. They found that the four companies investigated provide PGC, i.e., apparel customisation, by enabling the customer to avail a platform based on the wearable hobby through 3D scanner input of the user's body data. It is concluded that

the research provides a theoretical basis and data support towards sustainable development for the apparel industry (Ji et al., 2019).

Thorisdottir and Johannsdottir (2019) conducted a SLR, demonstrating initiatives of a fashion industry that integrates sustainability into business models. The authors reveal the need for expanded studies that refer to the fashion industry and sustainability. They believe that, innovations, regulatory issues, stakeholder outreach and value creation for the organisation are aspects that influence the integration of sustainability into business models, as companies tend to positively impact their stakeholders when they incorporate to their agendas, social and environmental responsibility practices, and corporate social responsibility.

Marques et al. (2020) highlight the circular economy's key role in promoting sustainability, since it promotes a new relationship of the subject with its goods and materials, which would ensure the preservation and saving of resources. According to the authors, there are two main circular economy business models: the first of them is focused on extending the life of objects and investing in reuse, reconstruction, reverse manufacturing/remanufacturing, and upgrades. The second, in turn, invests in recycling, either in the elaboration of a material to build other products with it (upcycling), or to transform these products into raw material (downcycling). The researchers reinforce the thesis that Generation Z and the millenials are the main public harmed by environmental conditions in the contemporary world, which is why these individuals also make up the main group demanding more sustainable actions. At the end of the article, the authors strongly advocate that business models should be adapted to the demands of environmental agendas.

Pero et al. (2020) reaffirm the trend that textile and apparel companies have been, in recent decades, seeking to adapt to a new production model that is in line with the principles of sustainability. They emphasise the importance of understanding the ethical dimension before the customer and the production process, because the selection of raw materials and retail processes directly impact the environmental relations produced by the industry. Thus, according to the authors, it is essential that companies develop sustainable marketing policies.

Gurova et al. (2020) address how sustainability must be present in wearable technologies to mitigate the effects of electronic waste, as of an adequate mapping of the product development life cycle. The stages that should be addressed for implementing technological solutions are material extraction, product distribution and disposal, production, use and disposal of products with finalised useful life.

Bullón Pérez et al. (2020) conducted a research on the use of blockchain technology, an open database that has digital information through which stakeholders can view and track garments. Such a resource includes different subjects, from the designers and sellers to the consumers of the final product. It allows the consumer to increase trust and control over the garments selected, making the middleman unnecessary in the buying and selling process. Moreover, it can be observed that this technology ensures the benefit of traceability of all elements involved in the production and sales process, which not only meets an ethical dimension of consumption, but also allows stakeholders to have greater knowledge about how the raw materials that give rise to their garments are obtained and manufactured. Thus, if a company uses more polluting or environmentally aggressive means to construct its garments, such information becomes accessible to the consuming public.

Brydges (2021) reports that circular economy principles that guided the Swedish fashion industry were fundamental to its contribution with sustainable development, avoiding considerable waste caused by this industry, since it is pointed out that the final stage of the consumption cycle of the clothing industry is the disposal of garments, even if they are still in usable condition. The author suggests that initiatives and interventions must compose all stages of the supply chain, not only the waste stage (understood by the use and subsequent disposal of clothing), but states that adherence to the circular economy model will not occur in a uniform manner, but rather heterogeneous and gradual, contemplating the particularities of each organisation and the consumer niche that frequents it.

Rhee and Lee (2021) reveal that fashion retailers have adopted AR as a resource to enhance the consumer experience in virtual shopping environments. They sought to identify whether there were relationships between virtual fit (VF) experience satisfactions, brand advocacy, mobile purchase intention, and offline purchase intention to understand how AR-based VF interferes with customer purchase intention, with customer engagement with the product as a moderating effect. In sum, the study revealed that virtual adaptation with AR impacts brand advocacy and purchase intent when performed on mobile apps. Such an initiative connects with I4.0 pillars by supporting a new way of selling and consuming, making the consumer much more connected, involved and engaged with the company and its products.

Braglia et al. (2021) emphasise the value of elements related to I4.0 for the resolution of typical supply chain problems from a strategy based on a chain of questions, the five-whys, from which it is possible to identify the root of the problem and then develop possibilities of action. According to the authors, it is essential that companies use tools and mechanisms to reduce inefficiency in the supply chain that enables the production of fashion-luxury, contributing to a production system that generates less waste of resources.

Youn and Jung (2021) aimed to recognise the perceptions of consumers of sustainable fashion with the use of big data SRS, from posts on social media, they performed the collection of keywords that were related to sustainable fashion. The most frequent words were “fashion, sustainable, eco-friendly, clothing, sustainability, ethics, conference, fast fashion, business and recycling” [Youn and Jung, (2021), p.13].

MacLennan et al. (2021) agree that eco-innovation is a significant contribution to the transformation of the planet’s reality from the use of technological or non-technological possibilities. The authors emphasise, in their findings, that the first is predominant in companies in the fashion sector, in Brazil, using the technological component in the processes in issues focused on reducing water and energy waste and eco-sustainable technologies.

Despite this, the authors also show that marketing and organisational eco-innovations, such as the adoption of certificates in the environmental area and the use of recyclable packaging are also relevant to be absorbed in the fashion industry. The conflicts between planned obsolescence and socio-environmental responsibility find support in I4.0 framed by the Fourth Industrial Revolution, and this is a way, when allied, to contemplate the interests of Y and X consumers, who have a strong tendency to over-consume. For this, business models must attribute value to sustainable design, to the conscious consumer, to resource savings, to modern and sustainable manufacturing processes and materials with advanced vibrations in this sustainable perspective (MacLennan et al., 2021).

Lee (2020) states that, increasingly, the supply chains that are adapting their technologies to the individual needs of customers have stood out. Therefore, he brings contributions, in this direction, focused on the creation of a supply chain for a system focused on real-time fashion, using 3D clothing production systems, with the contribution of ICTs, AI, and virtual environments. The author proposed to improve the purchasing conditions of consumers with the reduction of impediments such as distance, adaptation to specific needs and, in turn, meeting the precepts of a sustainable supply chain.

Continuing the search for good circular economy practices, D'Itria and Colombi (2022) add that the biological basis combined with innovations in design and the affective and relational issues of biomaterials consist in bio-based textile solutions that awaken the consumers of this industry in Europe to create affective interaction dynamics with the brands, in such a way that it is evident the tendency of the consumer niche to privilege companies that effectively engage in sustainability projects. The authors point out that there is, in this context, a greater chance of raw materials being reinserted into the production process, gaining new functionality by being reused.

Charnley et al. (2022) reinforce that despite organisational strategies adopted to include sustainable alternatives to reduce greenhouse gas emissions and waste from the textile industry's activity, there is still a lot of resistance in the acceptance as to the inclusion of bioderived alternatives and clothing recycling proposals by the consumer. The authors discuss the sale of second-hand clothing, a measure that they consider to be highly sustainable, since the reuse of clothing has proven to be more beneficial than recycling its materials. Even if they identify that the consumption of second-hand pieces is considered unattractive to consumers, the researchers defend that I4.0 strategies can mobilise the stakeholders so that they adhere to the proposal of these sales models. They also highlight the relevance and opportunities brought by technology as a way to increase the consumer's buying decision process in the textile industry, breaking the barriers established with the proposition of digital platforms, advanced image creation, product traceability, improved product taxonomy, filtering functionalities, better communication and transparency with the customer, among other aspects. Charnley et al. (2022) reinforce that, despite the organisational strategies adopted for the inclusion of sustainable alternatives to reduce greenhouse gas emissions and the waste from the textile industry activity, there is still a lot of resistance in the acceptance of the inclusion of bioderived alternatives and clothing recycling proposals by the consumer. The authors discuss the sale of second-hand clothing, a measure that they consider to be highly sustainable, since the reuse of clothing has proven to be more beneficial than recycling its materials. Even if they identify that the consumption of second-hand pieces is considered unattractive to consumers, the researchers defend that I4.0 strategies can mobilise the stakeholders so that they adhere to the proposal of these sales models. They also highlight the relevance and opportunities brought by technology as a way to increase the consumer's buying decision process in the textile industry, breaking the barriers established with the proposition of digital platforms, advanced image creation, product traceability, improved product taxonomy, filtering functionalities, better communication and transparency with the customer, among other aspects.

Vijeyarasa and Liu (2021) portray about gender justice in the fashion sector as a tool to achieve the Sustainable Development Goals (SDG), in particular, the SDG 12, which establishes parameters to stimulate the guarantee of sustainable patterns of consumption and production. The authors seek that this sustainable standard has as pillars, sustainability, but also the responsibility and commitment to gender issues within the

fashion area. Are listed in the research, six main requirements for a sustainable fashion and guided by gender justice: fair tax, participation and voice, fair pay, gender equality in the community, responsibility for promoting gender justice. These results emerged from experience in the fast fashion industry (Vijeyarasa and Liu, 2021).

Still in the direction of initiatives aimed at achieving the strategic SDG, when it comes to industrial production, more specifically, decarbonisation and dematerialisation, Beier et al. (2022) investigated the development of companies of various sizes and industrial sectors in China, Germany and Brazil, aiming to understand the potential in these different countries to achieve SDG 12, aimed at ensuring sustainable production and consumption patterns. The authors point out that the higher the level of implementation of the principles associated with I4.0, so that the highest stage would comprise the insertion of environmental management systems appropriate to the dimensions of a given company. They argue, therefore, that the transformations required for the establishment of I4.0 concepts must be intertwined with the aggregation of sustainable value to the textile industry and the efficient use of resources.

Based on case studies of online platforms of companies from countries such as the UK, South Korea and the USA, Bae et al. (2022) state that these resale platforms have been expanding in the industry and present themselves with trends that aggregate the dimensions of environmental, economic and social sustainability. The benefits are related to the order of decreased resource consumption and reduced waste, as well as enhancing the reuse of materials that still have durability. Researchers recognise that the most evident target audience for these platforms is the MZ generation (comprising, therefore, the millenials and digital natives of Generation Z), especially those in their twenties and older, because this consumer niche tends to be more socially and environmentally engaged.

In Bangladesh, Khairul Akter et al. (2022) proposed a conceptual model for waste management in the textile and apparel industry with the perspective of achieving SDG 12, which addresses the pursuit of sustainable consumption and production. In this model, the proposed strategies for solid waste management are related to the implementation of a tracking process associated with the generation of a circular economy. The proposal is to create a process of identification and mapping of the flow-value of materials to verify the economic value of material waste and the added value of their waste. This would avoid, for example, waste, a recurring environmental problem in the textile and clothing industries. It is worth noting that in this study, conducted with 17 textile and garment factories, it was identified that "approximately 0.70 USD has been lost for each garment export" [Khairul Akter et al., (2022), p.19].

Li et al. (2022) address that, with the advent of the internet and the evolution of AI, there was the emergence of smart clothes, which consist of textile pieces manufactured through the use of more sophisticated technological resources, which make them more suitable for different contexts of use. The authors draw attention to the development of intelligent clothes that merge the functionality of clothing with aesthetics, thus aiming at the adhesion of a public that chooses to acquire quality materials and made with less polluting and/or more durable resources, thus avoiding waste in production and the inadequate disposal of parts. However, in view of the reduced useful life of fabrics and electronic devices, the durability and acceptance of these clothes must be accompanied by sustainable paradigms that advocate better waste management.

Table 5 Main impact factors on Sustainability 4.0 identified

Impact factors in Sustainability 4.0	*Reference*
Adherence to circular economy; extension of product life cycle; corporate social responsibility; adherence to shared economy; technological innovation; adherence to collaborative economy; waste reduction; increased socio-environmental awareness	Todeschini et al. (2017)
Waste reduction; augmented reality experiences; virtual fitting room experiences; on-demand production; focus on customer experience	Bellemare and Carrier (2017)
Increased socio-environmental awareness; optimisation of resources; reduction of waste; perception of added value to the product; corporate social responsibility	Shen et al. (2017)
On-demand production; customisation; waste reduction; economy of resources	Ma et al. (2018)
Insertion of technology in production processes; reduction of resource consumption (water, energy, labour); reduction of carbon emissions; reduction of waste production; blockchain	Fu et al. (2018)
Sustainable supply chain; improving business models; establishing sustainable patterns of production and consumption; increased efficiency in the production process	Moretto et al. (2018)
Customisation; technological innovation; increased production efficiency; increased socio-environmental awareness; focus on customer experience	Bertola and Teunissen (2018)
Technological innovation; product life cycle assessment; customisation; focus on customer experience; reduction of environmental footprint; energy savings; resource savings; greater efficiency of the production process	Ji et al. (2019)
Adherence to corporate social and environmental responsibility; perception of value added to the product	Thorisdottir and Johannsdottir (2019)
Adoption to circular economy; increased environmental awareness; remanufacturing; saving resources, waste reduction; corporate social responsibility; product life cycle extension	Marques et al. (2020)
Increased socio-environmental awareness; reduced environmental footprint; adherence to corporate social and environmental responsibility; increased production efficiency	Pero et al. (2020)
Product life cycle mapping; implementation of technological solutions; waste reduction; resource/raw material optimisation	Gurova et al. (2020)
Technological innovation; increased socio-environmental awareness; focus on customer experience; transparency in production processes; economy of resources; corporate social responsibility; blockchain	Bullón Pérez et al. (2020)
Adherence to circular economy; waste reduction; sustainable supply chain; optimisation of resources	Brydges (2021)
Technological innovation; focus on customer experience; personalisation	Rhee and Lee (2021)
Reduction of waste; reduction in the use of resources; increased production efficiency; improved production processes	Braglia et al. (2021)
Sustainable fashion; technological innovation; waste reduction; focus on customer experience; big data	Youn and Jung (2021)

Source: The authors (2022)

Table 5 Main impact factors on Sustainability 4.0 identified (continued)

Impact factors in Sustainability 4.0	*Reference*
Eco-innovation; waste reduction; technological innovation; conscious consumption; increased environmental awareness; corporate social and environmental responsibility; adoption of eco-sustainable technologies; sustainable design; optimisation of resources; modernisation of production processes of manufacturing	MacLennan et al. (2021)
Technological innovation; personalisation/fulfilment of individual needs; 3D clothing; artificial intelligence; sustainable supply chain	Lee (2020)
Optimisation of raw materials; reuse of resources; increased sustainable/ecological awareness; use of biomaterials as raw materials	D'Itria and Colombi (2022)
Decreased waste production; adherence to circular economy; reuse of products; increase of product life cycle; adherence to new business models; technological innovation; reduction of gas emissions; improvement of production processes; focus on customer experience	Charnley et al. (2022)
Corporate socio-environmental responsibility; establishment of sustainable patterns of production and consumption	Vijeyarasa and Liu (2021)
Eco-innovation; waste reduction; technological innovation; conscientious consumption; increased environmental awareness; corporate social-environmental responsibility; adoption of eco-sustainable technologies; sustainable design; optimisation of resources; modernisation	Beier et al. (2022)
Digitalisation adherence to circular economy; extension of product life cycle; reduction of resource consumption; resale of products; adherence to new business models; reduction of resource consumption	Bae et al. (2022)
Establishing/ensuring sustainable production and consumption patterns; adhering to a circular economy; efficient waste management; reducing waste	Khairul Akter et al. (2022)
Technological innovation; adherence to less polluting raw materials; waste reduction; digitalisation; artificial intelligence; adequacy of disposal processes	Li et al. (2022)

Source: The authors (2022)

The factors identified, per article, as impacting sustainability in the fashion industry and important for the construction of this survey were condensed in Table 5.

4.3 Discussion

Many of the notable studies obtained at the end of this SLR address issues related to the impacts caused by traditional manufacturing systems in the textile and apparel industry, however, not exactly inserted directly into the context of Sustainability 4.0, the scope planned for the research, which leads to the apprehension about the existence of a gap in the literature and the consequent need to highlight the theme, contributing to the construction of its concepts. Even so, all the publications gathered at the end of the RSL process were kept and considered relevant for contributing to the surveyed data.

From the descriptive analysis, it is possible to observe, as illustrated in Figure 4, that there is a predominance of relevant studies in countries considered more developed, indicating their search for understanding around the theme proposed for this research, generating a warning that developing countries should also seek to promote research and development (R&D) for issues related to technology and sustainability in the textile and

apparel sector. Such observation can be correlated to the fact that the adoption of new technologies, in general, is conditioned to a greater capacity of resources availability for such investments, which configures a transition barrier to the I.4.0 scenario. "In I4.0, there are also barriers and issues that still require extensive research. These barriers include the cultural viability of the proposed models and the necessary support from governments" [Bonilla et al., (2018), p.3740].

The narrative analysis clearly notes, the trend towards technological innovation and/or digitalisation/digital transformation, evidenced when in 18 of the selected articles several scholars address Technologies 4.0 and their uses. Fu et al. (2018) and Bullón Pérez et al. (2020) brought the look from the blockchain perspective, Youn and Jung (2021), about big data, and Li et al. (2022) about AI, being inclusively, some of these articles, already directly applied to the fashion industry, as Bellemare and Carrier (2017) and Lee (2020), when dealing with the experiences with virtual fitting rooms, AR and 3D clothing, respectively.

The trend of consumers with greater social and environmental awareness, with the millennials and Z generations being the highlights, as already observed by Shen et al. (2017) and Bae et al. (2022), in their studies. 'Connected' generations, extremely familiar with technology, and that prioritise values and experiences in their consumption relations. Therefore, the marketing impact of these generations on the economy is quite significant. These new consumers offer excellent opportunities, but also pose great challenges for companies (Weetman, 2019), as they seek purpose and transparency in their choices of brands and products, imposing environmental and social requirements, for example. In addition, they also value the quality of the journey/experience of their purchases, and even consider paying more to have, for example, a personalised product that highlights their individuality.

Another relevant point for discussion, focuses on the positive trend, even if driven by different variables, of the incorporation, by organisations, of corporate social and environmental responsibility actions and practices, since, sustainability in fashion cannot be preempted to a secondary role. It becomes necessary to integrate it deeply into the corporate policy and strategy of companies (McKinsey & Company, 2019) and quickly adopt these sustainable guidelines (Choi and Han, 2019; Grose, 2019).

A significant number of the selected articles show the presence of the circular economy, indicating a continuous movement towards business models with this approach. Circular economy decouples companies' growth from resource consumption (Weetman, 2019), representing a systemic change that builds long-term resilience, generates economic and business opportunities, and provides environmental and social benefits. There are numerous and increasing possibilities for new and appropriate solutions for industrial remanufacturing, for the recirculation, reuse and/or reuse of textile waste.

Still from the narrative analysis, it was found in the studies, propensity to the insertion of technology and sustainability in the supply chains of companies, as Moretto et al. (2018), Brydges (2021) and Lee (2020) believe. The scope and complexity of supply chains will need to increase to meet these new needs (Weetman, 2019), after all, sustainability needs to accompany a business from the collection of raw materials, through production and arriving at the delivery of products to the consumer, increasing transparency, considerably reducing waste, optimising the logistics process and improving resource utilisation, especially in sensitive sectors and those with a critical socio-environmental footprint, such as the fashion industry.

Sustainability is one of the drivers of I4.0 an industry initiative that through the adoption of digital technologies on the assembly line is transforming traditional factories into smart factories (Thoben et al., 2017). Just as for the entire industrial production sector, for the textile industry, it is a fact that there is an indissoluble link between the economic, social, and environmental spheres.

Table 6 Impact factors for Sustainability 4.0 by TBL dimensions

Dimensions of TBL	*Number*	*Impact factors in Sustainability 4.0*
Economic	1	On-demand production
	2	Technological innovation
	3	Resource optimisation
	4	Adherence to circular economy
	5	Sustainable supply chain
	6	Increased efficiency in the production process
	7	Improvement of production processes
	8	Waste reduction
	9	Blockchain
	10	Insertion of technological solutions in the productive processes
	11	Joining the collaborative economy
	12	Product life cycle assessment
	13	Remanufacturing or reverse manufacturing
	14	*Big data*
	15	Joining the sharing economy
	16	Digitalising
	17	Product life cycle mapping
	18	Artificial intelligence
	19	Implementation of technological solutions
Social	20	Corporate socio-environmental responsibility
	21	More conscious consumption
	22	Focus on customer experience
	23	Personalisation
	24	3D clothes
	25	Sustainable fashion
	26	New business models
	27	Establishing sustainable production and consumption patterns
	28	Augmented reality
	29	Virtual testers
	30	Perception of value added to the product
	31	Transparency in production processes

Source: The authors (2022)

Table 6 Impact factors for Sustainability 4.0 by TBL dimensions (continued)

Dimensions of TBL	*Number*	*Impact factors in Sustainability 4.0*
Environmental	32	Eco-innovation
	33	Product life cycle extension
	34	Reduction of waste production
	35	Reduction of environmental footprint
	36	Waste reduction
	37	Use of biomaterials as raw materials
	38	Reduction of carbon footprint
	39	Efficient waste management
	40	Sustainable design
	41	Energy efficiency
	42	Adherence to less polluting raw materials
	43	Adequacy of the disposal processes
	44	Product life cycle extension
	45	Economy of resources (water, labour, energy, fibres, etc.)
	46	Adoption of ecosustainable technologies

Source: The authors (2022)

Table 6 then systematically demonstrates a compendium of the previously identified Sustainability 4.0 impact factors for each of the 26 articles, linking them to the three dimensions established by the TBL. Thus, a synthetic total of 46 factors listed around the textile and apparel manufacturing sector was obtained.

5 Conclusions

From the systematic review of the literature, it was possible to identify 46 factors that affect Sustainability 4.0 in the fashion industry, based on the dimensions established by the TBL theory, with 19 factors linked to the economic dimension, 12 to the social dimension and 15 to the environmental dimension. The identification of these factors contributes to making production processes in the fashion industry increasingly sustainable, in addition to pointing out ways for social and technological development through innovation.

In this sense, innovating in sustainable production processes implies investment through technological changes that generate opportunities for competitive gain. It is necessary to talk about renewable technological growth, when companies innovate, for example, in technologies capable of making better use of raw materials, promoting, among many other benefits, the reduction of waste, remanufacturing products, reducing the production of waste and carrying out an efficient management of these, or even creating value networks and new business models.

It was observed the synergistic and positive relationship between the themes in almost all stages, indicating that the alignment to sustainability effects the sustainable relationship between the advancement of industrial technologies. From this study, practical questions arise that can contribute managerially to the entrepreneurs, managers,

and leaders of organisations in the fashion industry. Such findings may also support the various actors involved in the textile and apparel industry, including consumers, to work as agents of change for sustainability, able to identify opportunities and limiters to the implementation of this transition. From this study, practical questions arise that can contribute managerially to entrepreneurs, managers and leaders of organisations in the fashion industry.

The research provides theoretical basis and data support towards sustainable and technological development for the apparel industry. Also noteworthy is the indication of trends for the textile production chain and the market that guide the performance of new exploratory studies and the search for new paths towards a transition to sustainability through the adoption of new technologies involved in the implementation of I4.0. The main limitation of the study is the lack of structured concepts of Sustainability 4.0, as it is a fairly new topic, which limits the collection of articles on the topic. In order to reduce this limitation, the authors sought to structure a concept of Sustainability 4.0 and from it identified the keywords for carrying out the RSL.

Based on the results of the study, it is suggested that more research be developed and as a suggestion for future work, it is recommended to develop an approach to Sustainability 4.0 in the fashion industry, using the interpretive structural modelling (ISM) model, aiming to point out the contextual relations of the factors identified in the RSL, the creation of a data collection instrument from the 46 dimensions to measure the degree of maturity of organisations and the development of a data collection instrument to collect the perception and importance of sustainability in the view of the customers.

In this way, this article presents its contribution through insights based on trends, which will positively guide the Fashion Industry towards the implementation of I4.0 and the development of industrial and technological models. This article reinforces the importance of applying new technologies in production processes, including throughout the entire value chain, in response to the challenges that arise in the textile market, in addition to encouraging new studies towards Sustainability 4.0 in the Fashion Industry.

Acknowledgements

The authors are grateful for the support received to conduct this study from the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) – Financing Code 001, the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and the Fundação de Amparo a Ciência e Tecnologia de Pernambuco (FACEPE).

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