



# Plastic pollution mitigation strategies in global supply chains: A thematic analysis

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**Background:** The extensive use of plastic in global supply chains (GSCs) has a profound impact on ecosystems and human well-being. Therefore, it is essential to implement an integrated strategy that takes into account the intricate interplay between economic factors, consumer behaviours, industrial practices, and environmental consequences to effectively address the plastic problem in global supply chains.

**Objectives:** This study explored the factors that contribute to plastic pollution in GSCs and proposed solutions.

**Method:** A thematic analysis of peer-reviewed articles, grey literature, and case studies of corporations implementing measures to reduce plastic pollution was conducted.

**Results:** Variables including production, material economics, marketing techniques, consumer choices, insufficient recycling facilities, regulatory frameworks, and GSC complexities have an impact on plastic pollution. Remedies like sustainable alternatives, circular economy methods, and extended producer accountability confront obstacles such as expenses, scalability, consumer acceptance, technological constraints, and policy fragmentation.

**Conclusion:** Addressing the issue of plastic pollution in GSCs is a challenging task that demands extensive and collaborative solutions. Currently, the mitigation strategies in place have several limitations, such as the absence of personalisation, cooperation, consumer involvement, and technological progress.

**Contribution:** This study provides a holistic analysis of plastic pollution in GSCs, establishing a theoretical framework that incorporates environmental, economic, and social aspects of sustainability. It also offers practical suggestions for businesses to adopt more effective plastic waste reduction strategies and to enhance supply chain management practices.

**Keywords:** plastic pollution; interdisciplinary approaches; supply chain; sustainability; environmental challenge; circular economy.

## Introduction

Plastic pollution in global supply chains (GSCs) has become a pressing environmental challenge in the 21st century (Bandh et al. 2023; Istrate et al. 2020). Despite the numerous advantages associated with the ubiquity, durability, and economic efficiency of plastics, they incur substantial environmental costs (Matheson 2022).

The prevailing linear model of 'make-disposal' has resulted in the accumulation of large quantities of plastic waste, which poses a significant threat to ecosystems, public health, and global market sustainability (Hawkins & Madden 2023; MacLeod et al. 2021). Fletcher et al. (2023) show that under a business-as-usual scenario, global plastic waste production is projected to nearly triple by 2060. Approximately half of this waste is expected to end up in landfills, whereas less than one-fifth is expected to be recycled (Borrelle et al. 2020; Law & Narayan 2021). The potential consequences of indelible plastic pollution include modifications to carbon and nutrient cycles; habitat alterations in soils, sediments, and aquatic ecosystems; co-occurring biological impacts on endangered or keystone species; ecotoxicity; and related societal impacts (MacLeod et al. 2021).

Eliminating the scourge of plastic pollution from Earth has become a global priority for governments, industries, and academic institutions (Abdel Kader & Qutb 2023; Gothár & Schanz 2024; Rabiú & Jaeger-Erben 2024). Nonetheless, the disparate nature of research on plastic

pollution has impeded efforts to identify and implement effective solutions for plastic pollution (Kurniawan et al. 2023; Rochman 2020).

Researchers (Barrowclough & Birkbeck 2022a; Pollard & Marzano 2023) with diverse disciplinary backgrounds and expertise, such as environmental science, biology, chemistry, material science, health sciences, economics, public policy, engineering and technology, social sciences, and geography studies, have contributed to existing research on plastic pollution. This issue spans various sectors and regions and has resulted in a fragmented body of research (Danopoulos et al. 2023; Liboiron et al. 2023; Oturai 2023).

Research on plastic pollution is therefore, often compartmentalised into disciplinary silos, industry-specific studies, and regional research, hindering the development of comprehensive and unified mitigation strategies (Danopoulos et al. 2023; Moshood et al. 2022). The current state of research on plastic pollution in GSCs is marked by a lack of cohesion owing to the disparate nature of industries, geographical locations, and the methodological approaches employed. This fragmentation leads to inconsistent data and findings, which in turn impedes the identification of common patterns in plastic pollution and assessment of its overall impact. Furthermore, the absence of standardised terminology and definitions for plastic pollution exacerbates this problem, as studies often employ varying metrics and benchmarks that make it challenging to compare outcomes and develop a unified framework for assessing strategy effectiveness. Systematic integration of data and findings is essential to effectively inform and create successful mitigation strategies, necessitating a concerted effort to align research methodologies and standardise terminologies across studies. This will bridge the gaps between different findings and provide a foundation for an integrated understanding of the global impact of plastic pollution, as well as development of effective countermeasures.

To address this issue, we conducted a systematic literature review to map the field and systematically identify strategic approaches for dealing with plastic pollution in global value chains. By doing so, we can consolidate and integrate the existing knowledge and provide the main findings regarding this subject. A systematic literature review is a powerful tool for consolidating, evaluating, and synthesising existing knowledge on a subject, contributing significantly to the development and refinement of an integrated body of knowledge in a specific field of study (Page et al. 2021). This review aims to synthesise research across disciplines, industries, and geographies to create a unified body of knowledge. It provides an objective analysis of global plastic pollution, offers a consolidated view of policy implications, and highlights innovative solutions and best practices across various sectors. This review transcends regional narratives and presents a comprehensive global perspective that

acknowledges the unique challenges and nuances encountered by distinct regions. This cross-regional synthesis is essential to uncover the underlying global trends in plastic pollution while respecting local contexts, thereby supporting the development of responsive and inclusive strategies that are sensitive to the socioeconomic and environmental intricacies of each area. This approach ensures that the devised global strategies are both applicable and adaptable to regional capacities and needs, paving the way for truly global solutions to plastic pollution in GSCs. Thus, the intention of this synthesis is to foster a multifaceted understanding of the factors fuelling plastic pollution that integrate regional insights into a GSC management context, setting the stage for globally informed, yet regionally tailored supply chain management policy frameworks. By encapsulating a diverse range of regional experiences and supply chain strategies, policymakers and stakeholders can be equipped with a more nuanced and effective toolkit to address the complexities of plastic pollution in GSC networks. This approach not only aligns with global Sustainable Development Goals (SDGs) but also ensures that actions taken are considerate of the varied dynamics at play across different geographic and industrial landscapes.

The remainder of this article is organised as follows. Initially, we establish a conceptual boundary to precisely define the plastic pollution in GSCs. Subsequently, we outline the methodology employed, detailing our systematic approach to literature selection and review, including information on our search strategy, analysis process, and evaluation of study quality. Next, we present the outcomes of the systematic literature review. Finally, we discuss the implications and limitations of our study, and propose key areas for future research.

## Conceptual demarcation

Plastic refers to any synthetic or semi-synthetic organic polymer that can be moulded in various forms (Kurniawan et al. 2023; Li et al. 2022; Moshood et al. 2022). Plastic pollution pertains to the accumulation of plastic objects and particles in the environment, which have detrimental effects on humans, wildlife, and their habitats (Oturai 2023). The study of the relationship between the flow and stock characteristics of plastics in GSCs is an emerging academic research field. This literature review brings together interdisciplinary studies to gain insights into how this interaction exacerbates environmental concerns. Rochman et al. (2019) provided a foundational resource that elucidated how plastics traverse global value chains from raw material extraction to waste. They emphasised the environmental consequences at each stage, arguing that the widespread use of plastics inevitably leads to increased stocks because of improper disposal. Their work lays the groundwork for understanding the intrinsic connection between the flow and subsequent stock. Horodytska et al. (2019) examined global recycling efforts and shed light on the disparities in international recycling infrastructure. They revealed the

shortcomings of current systems that fail to sufficiently redirect the flow of post-consumer plastics away from stock accumulation. Hawkins and Madden (2023) examined policy fragmentation, which allows for the continued proliferation of plastic materials in global value chains without adequate end-of-life strategies. They argued that this leads to unintended waste stocks, particularly in regions with weaker waste management policies, illustrating the symbiotic relationship between flow processes and stock outcomes. The United Nations Environment Programme (UNEP) report offers a comprehensive account of the cross-border impacts of plastic waste stocks, particularly in oceans (Walters & Fuentes Loureiro 2020). The report serves a crucial function in establishing a link between the international trade in plastics and the emergence of transboundary pollution stocks. Scholarly contributions from Brooks, Wang and Jambeck (2018) underline the significance of examining socioeconomic factors that impact the movement and accumulation of plastic waste in developing regions, highlighting that economic disparities often contribute to uneven stock distribution. Bakker et al.'s (2021) proposal for a circular economy anticipates that transforming the flow characteristics of plastics can effectively address the challenges associated with stock accumulation. They recommend incorporating end-of-life considerations at the design stage to significantly reduce environmental stock and alter global value chain dynamics.

The collective body of literature underscores a critical issue – inefficiency and inconsistency in the management of the plastic life cycle creates a vicious cycle that exacerbates environmental stocks, endangers ecosystems, and exacerbates socioeconomic disparities (Al-Shihabi & Barghash 2023; Law & Narayan 2021).

Furthermore, insufficient global policies to address this issue have compounded this challenge. A holistic forward-looking approach is necessary to align the movement of plastics in GSCs with environmental stewardships (Abdel Kader & Qutb 2023; Barrowclough & Birkbeck 2022b). Without this alignment, the accumulation of plastic waste will continue to compromise ecological integrity and human health on a global scale, rendering current and future remediation efforts costly and ineffective (Kumar, Maurya & Raj 2023; Landázuri et al. 2023; Maqsood & Altaf 2023). The literature (e.g., [Anderer, Dür & Lechner 2020; Castaldi et al. 2023; Fan, Anwar & Zhou 2023; Gentile et al. 2023]) also reveals a complex interplay in which the qualities that make plastics valuable in GSCs – their durability and versatility – also make their stocks environmentally pernicious. Although plastic materials facilitate global trade and development, their persistent residue serves as a symbol of unsustainable growth, a duality that underscores the urgent need for action from researchers, policymakers, and industry stakeholders (Danopoulos et al. 2023; Gentile et al. 2023; Moshood et al. 2022; Rosenboom, Langer & Traverso 2022; Tapaninaho & Heikkinen 2022).

## Methodology

The purpose of this literature review is to identify and summarise effective strategies for reducing plastic pollution in GSCs, in line with the goal of achieving global sustainability. To achieve this, we formulated a research question that asked what measures can be taken to minimise plastic pollution in GSCs. We followed a systematic approach to gather and evaluate relevant literature, adhering to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), to ensure a transparent report on our purpose, methodology, and findings (Page et al. 2021).

## Eligibility criteria

To ensure that our systematic review was comprehensive and focussed, we established a strict criteria for selecting relevant literature. Our review included peer-reviewed research articles, case studies, and grey literature that discussed plastic pollution mitigation in supply chains. Exclusion criteria was studies that did not focus on supply chains, non-English language articles, and publications before 2014. The literature review included directly examining strategies for mitigating plastic pollution within GSCs and evaluating the effectiveness of interventions in this context. We also examined practical applications and case studies relevant to the GSC framework and the contributions that consider policy implications and alignment with international sustainability objectives.

## Information sources

Our search encompassed a variety of databases, including Web of Science, Scopus, Business Source Complete, ScienceDirect, reports from the environmental organisation, GreenFILE, and grey literature databases, particularly the Open Grey System for unpublished research and policy articles. All database searches were conducted from 15 December 2023 to 05 January 2024 to ensure the inclusion of the most current research available. In addition, we conducted a general web search using Google to identify relevant unpublished literature and organisational websites that could provide supporting information. Our goal was to gather a wide range of studies to mitigate potential bias and to identify the full scope of evidence related to this topic. Furthermore, we selected various case studies in our review following a structured approach, whereby we initially applied meticulous criteria for selecting case studies that were directly relevant to plastic pollution mitigation in GSCs. Each case study was then analysed, with a focus on identifying the context, intervention strategies, outcomes, and lessons learned. This involved a detailed examination of the implementation processes, stakeholder engagement, challenges faced, and effectiveness of the mitigation strategies applied. To ensure consistency and unbiased analysis of each case study, we used a standardised template to extract and compare information. This allowed for a systematic synthesis of the knowledge gained from various contexts and interventions, providing a comprehensive view of the

practical applications and real-world impacts of mitigation strategies. The findings from the case studies were then integrated with broader literature to construct a multidimensional understanding of the issue at hand.

## Search strategy

We used a diverse array of search strategies aimed at comprehensively retrieving relevant information to achieve high levels of conceptual saturation and maximal variability. Keywords employed in the search included 'plastic pollution', 'supply chain', 'mitigation strategies', 'waste management', and 'sustainability'. We also adapted a search string for each database's syntax, limiting our search to the titles, abstracts, and keywords. The search string was adapted for each database's syntax involved combining subject headings and search terms, such as 'plastic pollution' AND 'global supply chains' OR 'global value chains' OR 'supply chains', to locate studies focussed on reducing plastic pollution in GSCs. For the case studies, the search strategy involved keyword development, which was based on a search query that combined key terms related to our research question, including 'plastic pollution', 'case study', 'mitigation strategies', and 'global supply chain'. The search was conducted using the Google search engine by applying advanced search parameters to filter the results by relevance and timeliness. We set parameters to prioritise authoritative sources such as governmental agencies, non-governmental organisations (NGOs), and industry publications. Thereafter, the initial search results were manually screened to identify links directed to potentially relevant case studies. We prioritised documents and reports that provided an in-depth analysis and discussion of mitigation strategies within the context of supply chains. Full-text documents or summaries of the case studies identified through Google search were retrieved for further assessment. Where necessary, we conducted follow-up searches using specific report titles or authors to locate full studies. Each retrieved case study was assessed against our predetermined inclusion criteria, which emphasised the relevance of plastic pollution mitigation in GSCs, adequacy of data, and methodological rigour.

## Study selection

Duplicates were removed before the two reviewers independently screened the titles and abstracts of the relevant studies. Thereafter, an eligibility checklist was used by one of the researchers to screen all the titles and abstracts for relevance, moving each to one of the three groups created within the Zotero Library titled 'relevant', 'irrelevant', and 'uncertain'. A second reviewer then screened 30% of the 'irrelevant' group citations as a check on the first reviewer's decision-making consistency. We then obtained full text articles for each citation in the 'relevant' and 'uncertain' groups, which we independently reviewed to determine their relevance. Disagreements between the reviewers were discussed until a consensus was reached. As a result, the full

texts of potentially eligible studies were assessed independently. Disagreements were resolved by discussion. To identify relevant case studies on plastic pollution mitigation in GSCs, we integrated the use of Google with our primary database searches to encompass a broader spectrum of applied research and grey literature. We prioritised documents and reports that provided an in-depth analysis and discussion of mitigation strategies within the context of supply chains. By employing this structured approach to search Google for case studies, we aimed to complement the systematic literature review with practical examples of how plastic pollution mitigation strategies have been applied in various GSC contexts. This strategy ensured a comprehensive collection of case studies to inform our review of real-world practice.

## Mitigating the risk of bias

To ensure a precise evaluation of the risk of bias in the selected studies in our review of plastic pollution mitigation strategies, we followed the Cochrane Handbook's recommendations for comprehensive searches to mitigate publication and selection bias. We adopted a meticulous approach that included a comprehensive and systematic search strategy that entailed individual researchers conducting independent, comprehensive database searches with predetermined search terms across all the included databases and grey literature (Cumpston et al. 2019). In addition, titles and abstracts were screened and studies were selected based on the defined inclusion criteria. We also employed a cross-referencing technique in which we juxtaposed the reported results and data of each study against supplementary data sources, such as datasets from reputable environmental organisations and official statistics, to verify the accuracy of the extracted data (Ryan et al. 2021). Furthermore, we performed a comparative analysis of reported outcomes with analogous studies in the field (Kumar et al. 2022). This process encompasses examining the consistency of results and methodologies across different research works to validate our findings and ensure the reliable integration of data.

## Data synthesis

In our systematic literature review, we employed thematic synthesis, a method used to identify, analyse, and report patterns (themes) within the data. This qualitative analytical approach is structured to distil complex information into overarching themes that succinctly capture core issues and insights from literature (Compernelle et al. 2020). Using this method, we sought to effectively present and summarise the results and provide a clear narrative of the findings related to plastic pollution mitigation strategies. This approach was chosen for several reasons. Firstly, we projected having to synthesise many studies, and the thematic synthesis was judged to be more appropriate for that goal than the other methods (Damarell et al. 2020; Thomas & Harden 2008). Secondly, this thematic synthesis approach extends beyond mere quantification of concepts by employing a process of

pattern recognition across diverse studies (Shahi et al. 2020). Thirdly, thematic synthesis provides a systematic and transparent approach to conducting and reporting the review through its three clearly delineated stages, which involve line-by-line inductive coding of findings within the primary studies, organising any related 'codes' into descriptive 'themes', and creating more abstract 'analytic themes' (Damarell et al. 2020). The findings were categorised into recurrent themes and subthemes that describe various facets of mitigating plastic pollution in GSCs. Additionally, a detailed discussion section was included, where the implications of the synthesised data on the effectiveness of the identified strategies were interpreted, along with confidence in these estimates and the need for further research. The synthesis method ensured a structured, systematic, and transparent process for collating and presenting the findings, which allowed us to draw clear conclusions regarding strategies that are effective in mitigating plastic pollution within GSCs.

## Results

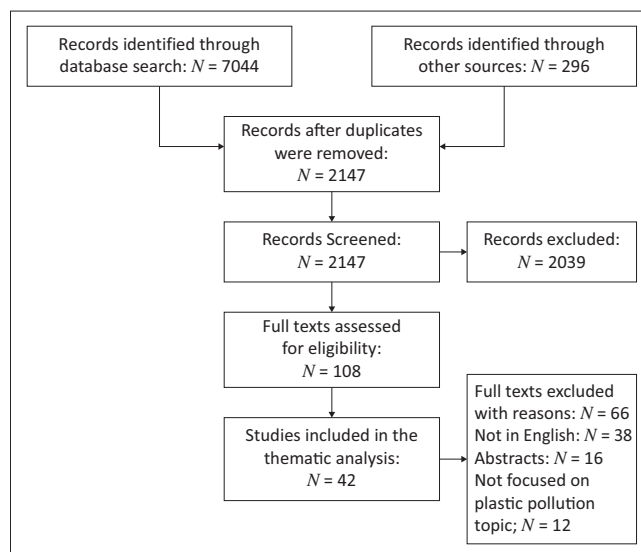
This section describes the outcomes of an in-depth analysis of diverse data sources encompassing systematic literature reviews and case studies. Our focus was to unravel the intricate dynamics of plastic pollution in GSCs. Here, we present a nuanced understanding of the scale, impacts, and potential solutions of the pervasive issue of plastic pollution in GSCs. The results herein form the basis for our informed discussions, actionable insights, and strategic measures to address the multifaceted challenges associated with plastic pollution globally.

### Search strategy and study selection

Our electronic database and grey literature, along with reference list checks, resulted in 7044 citations. After accounting for duplicates, we obtained 2147 citations. After scanning titles and abstracts against the inclusion criteria, 108 citations remained, requiring further review of full-text articles. After a more thorough full-text analysis, we ended up with 42 articles for the final synthesis. This process is outlined in Figure 1 as a PRISMA flow diagram (Page et al. 2021).

## Causes of plastic pollution in global supply chains

Our systematic literature review identified several interconnected themes and subthemes related to plastic pollution in supply chains. The following is a summary of the data categorised by these themes: single-use plastic pollution is a multifaceted environmental issue, with various factors contributing to its severity and persistence. These factors reflect the diverse lifecycle of single-use plastics, from manufacturing to disposal, and encompass a range of economic, social, and regulatory influences across GSCs. We discovered subthemes related to plastic pollution in GSCs.



Source: Adapted from Damarell, R.A., Morgan, D.D. & Tieman, J.J., 2020, 'General practitioner strategies for managing patients with multimorbidity: A systematic review and thematic synthesis of qualitative research', *BMC Family Practice* 21, 1–23.

**FIGURE 1:** Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram.

## Production and material economics

The discussion surrounding the economics of single-use plastic production is dominated by studies that emphasise the cost-effectiveness and efficiency of plastic manufacturing as key factors that contribute to its widespread use (Nikiema & Asiedu 2022). According to Chen et al. (2021), single-use plastics are primarily derived from fossil fuels, making them inexpensive to produce and economically attractive to manufacturers in GSCs. The choice of materials often prioritises cost efficiency over environmental impact, leading to a preference for disposable items. Moreover, single-use plastics illustrate market externalities, where environmental costs are not borne by producers or consumers, but by society (Matheson 2022). Without mechanisms to internalise these externalities, supply chains continue to exploit the economic benefits of single-use plastics. Several studies (Chen et al. 2021; Vimal et al. 2020) have found that low material and production costs create a comparative economic advantage for single-use plastics, resulting in an increased production volume. However, Matheson (2022) pointed out a critical disconnect in pricing structures that fails to account for the environmental externalities of single-use plastics, thereby perpetuating their unchecked flow in GSCs.

## Packaging and marketing practices

The literature underscores the significant role of marketing strategies in bolstering demand for single-use plastics. Vimal et al. (2020) shed light on how leaps in packaging technology not only enhance the appeal and prolong the shelf life of products but also anchor the use of single-use plastics in the retail sector. Walker et al. (2021) alluded that, in many cases, such innovative packaging has outpaced environmental concerns, thus reinforcing single-use plastics. In the consumer goods industry, the allure of packaging is not merely aesthetic but it also serves critical functions, such as product protection

and convenience, making it integral to modern marketing tactics (Dominic 2021). Other studies (Diana et al. 2022; Hawkins & Madden 2023) have found that single-use plastics are favoured by many companies because of their cost-effectiveness, durability, and flexibility, which makes them ubiquitous in product packaging. However, this also entails a significant increase in plastic waste because these materials are designed to be discarded after only single use. The studies taken together depict a marketing landscape finely tuned to a plastic-dependent model in which sustainability and the exploration of eco-friendly substitutes have often been secondary considerations. The emphasis on short-term functionality in packaging over long-term environmental impacts underscores the need to recalibrate marketing priorities for sustainable practices.

### Consumer convenience culture

A recurring theme in contemporary society literature is the prominence of consumer culture, which places a premium on convenience. This cultural tendency has been deeply ingrained by the prevalence of single-use plastics, as highlighted by Walker et al. (2021), who underscored how these materials cater to the immediate needs of consumers but at a significant long-term cost to the environment. Morsetto et al. (2023) highlighted that the rise of fast-paced lifestyles has further entrenched a disposable mindset, with individuals increasingly opting for products that offer time savings and ease of use, thus reinforcing a robust market for single-use items. Consequently, single-use plastics have proliferated in the form of food packaging, shopping bags, and beverage containers, a trend identified by Sun and He (2023) that contributes to the growing waste management crisis and environmental problems. This shift towards disposability reflects broader societal values, suggesting that substantial shifts in both individual behaviours and systemic practices are necessary to counter the environmental impacts of this consumption pattern.

### Inadequate recycling infrastructure

The escalating plastic pollution problem in GSCs is further aggravated by insufficient recycling systems, a theme echoed by Kibria et al. (2023), who pointed out that the capacity to manage large quantities of waste is unavailable in many regions. Other scholars (Li et al. 2022) found this challenge to be compounded by a narrow focus on recycling predominantly marketable plastics, leaving a surplus of non-recyclable plastics that contaminate the environment. In addition, as highlighted by Mihai et al. (2021), the practice of exporting plastic waste across international lines adds layers of complexity, exacerbated by the varying recycling capabilities and legislative frameworks among nations. In the economic sphere, studies (Gothár & Schanz 2024) have emphasised the competition faced by recycled plastics, which struggle to match the affordability of virgin plastics, thereby deterring investments in recycling innovation. This confluence of issues necessitates a comprehensive, research-informed strategy that promotes technological innovations in recycling,

stimulates a market for recycled goods, and aligns with global policies to reduce the prevalence of single-use plastics and their adverse environmental impact.

### Policy and regulatory frameworks

The literature on policy and regulation regarding single-use plastic pollution is bifurcated, presenting a complex picture of both the challenges and progress. On one side of the spectrum, researchers, such as Gentile et al. (2023), have drawn attention to the inconsistent and often ineffective nature of policies intended to regulate single-use plastics. These policies vary widely across jurisdictions, leading to piecemeal adoption and enforcement, limiting their overall effectiveness. Such measures may include bans or taxes on specific single-use items; however, without a global consensus or enforcement mechanism, their impact on pollution reduction remains largely localised. In contrast, literature shows that robust policies have led to substantial reductions in single-use plastic consumption (Borg et al. 2022; Rabiou & Jaeger-Erben 2024; Singh & Biswas 2023). Indeed, a comparative policy study by Marino and Pariso (2020) is foundational to understanding how different regulatory frameworks adapt to the complexities of international trade, as well as the propensities of individual nations participating in GSCs to attempt to mitigate or exacerbate the challenges of plastic pollution.

### Global supply chain dynamics

Literature (Al-Shihabi & Barghash 2023; Bor 2020; Liu et al. 2022) describes the mixed role of GSCs in the context of single-use plastic pollution. Global supply chains require durable, lightweight materials to minimise costs and maintain product integrity during transportation, consequently leading to increased usage of single-use plastics. However, they also have the potential to implement measures to mitigate the pollution. Faced with environmental regulations and consumer expectations, companies within GSCs are increasingly exploring sustainable alternatives, promoting reuse and recycling, and aiming to establish circular economies (Despoudi 2020; Xu, Liao & Sun et al. 2023). Additionally, as Sinkovics, Sinkovics and Archie-Acheampong (2021) highlight, powerful multinationals within these chains can enforce environmental standards at the supplier level, thereby expanding their sustainability initiatives. Thus, our systematic review reveals that GSCs stand at a juncture, serving both as conduits for single-use plastic pollution and channels for widespread sustainable practices.

### Public awareness and education

There is a growing awareness of the environmental impacts of single-use plastics, yet education and public engagement efforts vary significantly. Limited awareness and education about the detrimental effects of single-use plastics are accorded significant culpability for fuelling the prevalence of plastic pollution and associated environmental issues across the globe (Senturk & Duamludag 2022). Without a

broad understanding of the impact, consumers may not recognise the importance of reducing plastic use, leading to a continued high demand for convenient, disposable plastic products, as observed by Kittu, Aruljothi and Chellamuthu (2023). Furthermore, limited education on the topic means that many individuals may not know how to properly recycle or may be unaware of the recycling options available, as Borg et al. (2022) elaborated, resulting in higher volumes of plastic waste in landfills and the natural environment. This knowledge gap can also hinder consumers' demand for sustainable products. Efforts to inform consumers about sustainable alternatives and the importance of reducing plastic use are critical to changing usage patterns (Borg et al. 2022).

In summary, this review points to a complex interplay between economic incentives, cultural practices, market mechanisms, infrastructural limitations, and policy landscapes that sustain the flow of single-use plastics in GSCs. Each of these dimensions influences the extent of single-use plastic pollution and highlights the interconnectedness of the actions needed to mitigate this issue from material innovation and design to waste management and consumer education. Addressing single-use plastic pollution requires a multifaceted approach that acknowledges these dimensions and incorporates stakeholders across the entire life cycle of the plastic products.

## Solutions to plastic pollution in global supply chains

### Theme 1: Sustainable alternatives

The literature reveals the important role of sustainable alternatives in minimising the negative impact of plastics on GSCs. Driven by environmental concerns and regulatory demands, these alternatives aim to reduce reliance on traditional plastics through eco-friendly replacement and circular economic practices. Notable innovations in the literature include bio-based materials, reuse and refill systems, and recycling technologies that are shaping the transition towards a more sustainable global supply chain (Costa et al. 2023; Versino et al. 2023). In view of this, we also examined how the economic feasibility, market acceptance, and logistical considerations of these alternatives, as well as the challenges and opportunities they present in replacing single-use plastics are presented in the extant literature.

#### Bio-based materials

Bio-based materials such as polylactic acid and polyhydroxyalkanoates are universally identified as potential environmentally friendly alternatives to conventional single-use plastics, owing to their renewable origins and biodegradability (Abdelshafy et al. 2023; Costa et al. 2023; Versino et al. 2023). Nonetheless, it is evident in the literature that despite their potential to reduce the environmental impact and carbon footprint, significant challenges must be addressed before they can be adopted more widely (Asna Ashari, Oh & Koch 2024; Gerassimidou et al. 2021;

Landázuri et al. 2023). Rosenboom et al. (2022) highlighted the scalability of production, high cost, and variations in mechanical properties that limit their competitiveness with traditional plastics. Other studies (e.g., Khan et al. 2022; Ordoñez, Atarés & Chiralt 2022; Wei et al. 2017) have found that the biodegradability of bio-based materials is heavily dependent on the availability of specific composting conditions, thus casting doubt on their practical disposal and degradation in diverse environments. This suggests that further research is needed to improve production efficiency, material performance, and composting infrastructure to fully realise the sustainable potential of bio-based materials within GSCs.

#### Reusable packaging

Our systematic review demonstrates the significance of employing reusable packaging to address the issue of plastic pollution and that it requires a synergistic approach encompassing both behavioural modifications and system design. Numerous scholars (Pahl, Richter & Wyles 2020, Kibria et al. 2023, Oturai 2023) have underscored the potential of reusable packaging systems and have emphasised the need for a shift in consumer habits, infrastructure development, and design practices for their successful implementation. Fletcher et al. (2023) show that closed-loop and take-back programmes can contribute to a more sustainable future. However, many previous studies (e.g., Betts et al. 2022; Eisenreich et al. 2022; Kumar et al. 2023) have found that the success of reusable packaging is dependent on consumers' willingness to embrace new behaviours, the practicality of these systems, and the presence of robust infrastructure for the collection, maintenance, and redistribution of packaging. Existing literature indicates that the high initial costs involved in the implementation of reusable packaging remain a significant barrier for businesses. This underscores the need for strategic investments and consumer incentives to encourage widespread adoption and to ensure the long-term environmental impact of eco-conscious packaging solutions within GSCs (Kibria et al. 2023; Vanapalli et al. 2021).

#### Eco-friendly substitutes

The literature recognises how the use of eco-friendly alternatives to conventional plastics can be harnessed as a strategic approach to reducing plastic pollution in GSCs, as it offers benefits such as renewability and biodegradability (Mangal, Rao & Banerjee 2023; Moshood et al. 2022; Sheldon & Norton 2020).

However, the limitations of these alternatives have also been observed, including issues with the actual degradation conditions, production scalability, and higher costs (Abe et al. 2021; Thakur et al. 2018; Zaaba & Jaafar 2020). Additionally, the suitability of these materials for a variety of products, the need for broader market penetration, and the critical role of policies in promoting their adoption have also been highlighted (Baranwal et al. 2022). Therefore, it is clear from our review that transitioning to eco-friendly materials, requires a multifaceted approach that integrates material

innovation, economic strategies, and regulatory support to address the plastic pollution crisis effectively.

While the challenge of transitioning to eco-friendly materials is a well-documented issue in mitigating plastic pollution, our analysis offers a unique perspective by examining this transition, specifically within the context of GSCs. We argue that supply chains' global nature presents unique challenges and opportunities for this transition.

For instance, while the global reach of supply chains can complicate the transition owing to differing regulations and standards across countries, it also provides opportunities for learning and innovation transfer across borders. Furthermore, our analysis highlights the role of multinational corporations in driving this transition on a global scale. By focussing on these aspects, our study adds to the existing literature by providing a more nuanced understanding of the transition to eco-friendly materials in the context of GSCs'.

## Theme 2: Circular economy practices

Our systematic literature review reveals the widespread adoption of circular economy practices within GSCs, highlighting the urgent need for a transition towards more sustainable and regenerative models. Circular economy practices aim to replace the conventional linear 'take-make-dispose' approach with a sustainable closed-loop system that enhances resource efficiency and minimises waste (Bandh et al. 2023; Goyal, Esposito & Kapoor 2018). Such an approach can emphasise incorporating essential circular principles within GSCs encompassing closed-loop systems, design for recycling, and waste-to-energy solutions.

### Closed-loop systems

As a result of the environmental advantages of continuous recycling, several studies have focussed on the important role of closed-loop systems in fostering a sustainable circular economy (Maqsood & Altaf 2023; Reddy et al. 2023). However, despite the numerous benefits, the literature reveals that implementing such systems is a difficult endeavour for businesses in GSCs because closed-loop systems by their nature require sophisticated infrastructure capable of managing intricate material flows and ensuring the requisite product quality (Debnath et al. 2023; Marsh, Velenturf & Bernal 2022). Other studies (e.g., (Ahmed 2021; Amjad et al. 2022) have emphasised the significance of consumer engagement because successful recycling relies heavily on behaviour. Several studies (e.g., Andersen et al. 2023) found that the economic viability of closed-loop systems depends on the initial investment and long-term competitiveness with virgin materials, thereby necessitating strategic investments and policy frameworks that support recycled commodities.

### Design for recycling

Another key strategy in the circular economy relates to recycling design, which involves the proactive use of single materials to enhance material purity and recycling efficiency

(Antonopoulos, Faraca & Tonini 2021; Milios et al. 2018; Thompson et al. 2021), standardisation of components to streamline the recycling process through bulk handling (Kristoffersen et al. 2020; Morseletto 2023), and the easy disassembly of products to maximise resource recovery and prolong their life cycles (Alsafran et al. 2023; Wang et al. 2021). Rajaeifar et al. (2022) established that this requires collaboration between designers, manufacturers, and recyclers, as it faces challenges in aligning product functionality with recyclability, managing transition costs, and ensuring that standardised design aspects meet consumer expectations and approval. This evidence points to the necessity of integrated and innovative industry practices, guided by strong regulatory frameworks.

### Waste-to-energy solutions

Waste-to-energy (WtE) solutions have emerged as pivotal tools in GSCs, providing the dual advantages of waste management and energy production to address the challenges of plastic pollution. These technologies, including incineration, gasification, and anaerobic digestion, have contributed to a more sustainable and circular approach by converting waste into energy, reducing landfill dependence, and reducing the carbon footprint (Istrate et al. 2020; Longsheng et al. 2022; Porshnov 2022). However, the research laments the hindrances posed by obstacles such as high costs, environmental concerns regarding emissions, and technical challenges associated with diverse waste streams to the widespread adoption of WtE solutions. Other studies have claimed that public perception and community acceptance, along with the need for improved waste management practices, pose significant hurdles (Varjani et al. 2022). This suggests that navigating these challenges requires continuous innovation, research, and collaboration to enhance the effectiveness of WtE solutions in GSCs.

## Theme 3: Extended producer responsibility

Extended producer responsibility (EPR), a policy approach that shifts the responsibility for waste management and recycling upstream to the producers for the entire life cycle of products, has emerged as a crucial strategy for enhancing sustainability in GSCs (Hou et al. 2020; Leclerc & Badami 2020; Liu et al. 2022; Tumu, Vorst & Curtzwiler 2023). This approach encourages eco-friendly materials, recycling processes, and responsible product disposal, thereby contributing to a circular economy and reducing the environmental footprint. Despite its benefits, Leclerc and Badami (2020) observed that challenges persist in its widespread implementation as fairness is questioned across the supply chain. Furthermore, studies indicate that the harmonisation of regulations across diverse regions and industries, ensuring effective enforcement, managing compliance costs, and fostering public awareness are critical hurdles (Abdel Kader & Qutb 2023; Bening, Pruess & Blum 2021; Walker et al. 2021). It is clearly evident from the systematic review that collaborative efforts between governments, businesses, and consumers are essential to



ensure transparent and standardised frameworks, increase stakeholder engagement, and enhance accountability throughout the supply chain, which are intrinsic to the realisation of the full potential of EPR in transforming GSCs towards more responsible and sustainable practices.

## Case studies

After exploring various solutions to plastic pollution that encompass sustainable alternatives, circular economy practices, and EPR solutions within the complex dynamics of GSCs, we conducted an analysis of their real-world applications through a review of pertinent case studies (see Table 1). By examining specific instances where the strategies were implemented, our aim was to draw valuable insights into the success, challenges, and overall effectiveness of sustainability strategies. These case studies serve as practical illustrations and provide tangible examples of how these solutions can be integrated into a complex web of GSCs. Through this examination, we sought to enhance our understanding of the practical implications and potential refinements necessary for the successful implementation of these solutions to combat plastic pollution.

These case studies reinforce the assertion that mitigating plastic pollution in GSCs is a multifaceted task that involves both success and challenges across various strategies.

Biodegradable materials and recycling have proven to be sustainable alternatives that can effectively reduce single-use plastic wastes.

Nonetheless, the adoption of sustainable materials still faces challenges including higher costs and the need for broader implementation. Circular economy practices, such as reusable packaging in Loop UK and efficient waste management in Green Africa Recycling, have also demonstrated success in reducing single-use plastics and pollution. However, these practices encounter initial high costs, require consumer behaviour change, and require an expansion of waste management infrastructure. Navigating diverse industries, regulations, and socioeconomic contexts on a global scale remains challenging. Extended producer responsibility initiatives have successfully shifted responsibility to producers, but consistent enforcement, compliance, and cost management, including sourcing enough recycled materials and balancing cost-effectiveness, remain significant challenges. In addition, consumer awareness and participation remain crucial, emphasising the importance of engagement in circular practices. Finally, technological and logistics challenges underscore the need to overcome resistance and manage complexities in the collection and recycling processes. In essence, addressing plastic pollution requires a comprehensive and collaborative approach to navigate the multifaceted issues inherent in GSCs.

**TABLE 1:** Real-life adoption of sustainability practices in global supply chains.

Practices	Case study	Successes	Challenges
Sustainable Alternatives	Ecopack, South Africa – Ocean-Friendly Packaging <a href="https://ecopack.co.za/?s=plastic+pollution">https://ecopack.co.za/?s=plastic+pollution</a>	Substantial reduction in single-use plastic waste through the adoption of biodegradable and compostable packaging materials	<ul style="list-style-type: none"> <li>• Initial higher costs for sustainable materials</li> <li>• Consumer education required to embrace and understand the benefits of eco-friendly options</li> </ul>
	PETCO in South Africa <a href="https://petco.co.za/producers/understanding-epr/">https://petco.co.za/producers/understanding-epr/</a>	Successful promotion of polyethylene terephthalate (PET) bottle recycling, reducing the environmental impact of plastic bottles	<ul style="list-style-type: none"> <li>• Ongoing challenges in promoting broader sustainable material use</li> </ul>
	Adidas Parley Collection <a href="https://www.adidas.com/us/blog/639412-how-we-turn-plastic-bottles-into-shoes-our-partnership-with-parley-for-the-oceans">https://www.adidas.com/us/blog/639412-how-we-turn-plastic-bottles-into-shoes-our-partnership-with-parley-for-the-oceans</a>	Introducing sportswear made from recycled ocean plastics, raising awareness about marine pollution and providing a sustainable solution	<ul style="list-style-type: none"> <li>• Sourcing enough recycled materials for large-scale production</li> <li>• Balancing cost-effectiveness with sustainable practices</li> </ul>
Circular Economy Practices	Loop UK's Reusable Packaging, <a href="https://exploreloop.com/purpose/">https://exploreloop.com/purpose/</a>	Introducing reusable and refillable packaging solutions, reducing single-use plastic and promoting a circular economy model	<ul style="list-style-type: none"> <li>• High initial costs for implementing reusable packaging systems</li> <li>• Consumer behaviour change is essential for widespread adoption</li> </ul>
	TeraCycle, USA's Loop Programme <a href="https://www.terracycle.com/en-US/pages/345">https://www.terracycle.com/en-US/pages/345</a>	Creating a system for consumers to send back used packaging for cleaning and reuse, reducing waste and encouraging a circular economy	<ul style="list-style-type: none"> <li>• Building widespread awareness and participation in the Loop programme</li> <li>• Challenges in recycling certain materials</li> </ul>
	Green Africa Recycling in Botswana <a href="https://medium.com/@botscn/closing-the-loop-embracing-the-circular-economy-in-botswana-ffe0a2f9f857">https://medium.com/@botscn/closing-the-loop-embracing-the-circular-economy-in-botswana-ffe0a2f9f857</a>	Efficient collection and sorting of plastic waste, contributing to reduced plastic pollution and the creation of a supply chain for recycling industries	<ul style="list-style-type: none"> <li>• Expanding infrastructure for comprehensive plastic waste management</li> <li>• Raising awareness for widespread participation</li> </ul>
	Ellen MacArthur Foundation's New Plastics Economy World Economic Forum, Ellen MacArthur Foundation and McKinsey & Company, The New Plastics Economy: Rethinking the future of plastics (2016). <a href="https://www.ellenmacarthurfoundation.org/the-new-plastics-economy-rethinking-the-future-of-plastics">https://www.ellenmacarthurfoundation.org/the-new-plastics-economy-rethinking-the-future-of-plastics</a>	A global, multi-industry initiative that aims to accelerate business-driven innovations to help scale the circular economy	<ul style="list-style-type: none"> <li>• Dealing with diversity of industries, regulations, and socio-economic contexts across the world</li> </ul>
Extended Producer Responsibility	EPR Legislation in the European Union <a href="https://www.europen-packaging.eu/policy-area/extended-producer-responsibility/">https://www.europen-packaging.eu/policy-area/extended-producer-responsibility/</a>	Shifting responsibility to producers for managing the entire life cycle of products, encouraging sustainable design and waste reduction	<ul style="list-style-type: none"> <li>• Ensuring consistent enforcement and compliance across all EU member states</li> <li>• Balancing compliance costs for businesses, particularly small enterprises</li> </ul>
	EPR Policies in South Africa <a href="https://www.plasticsinfo.co.za/sustainability/extended-producer-responsibility/">https://www.plasticsinfo.co.za/sustainability/extended-producer-responsibility/</a>	Consideration of EPR policies for plastics, signalling a commitment to holding producers responsible for the life cycle of plastic products	<ul style="list-style-type: none"> <li>• Ensuring effective enforcement and compliance across diverse stakeholders</li> <li>• Addressing potential resistance and cost concerns among producers</li> </ul>

EPR, extended producer responsibility; EU, European Union.

## Discussion

The objective of this study is to investigate the various factors contributing to plastic pollution in GSCs and to suggest possible solutions to minimise plastic pollution in the global economy. This study underscores the significance of adopting context-sensitive solutions that leverage industry-specific knowledge and adapt them to local circumstances. It advocates an integrated framework that fosters cross-sectoral collaboration and emphasises the strategic importance of actively involving consumers as a critical component of the supply chain. Moreover, this study sheds light on the specific technological and logistical challenges that must be overcome to facilitate progressive innovation. By presenting these findings using newly gathered empirical evidence, this study contributes to the theoretical discourse on sustainable supply chain management and provides a solid foundation for future advancement in this field. This research suggests that current strategies are insufficient to achieve optimal levels of cooperation and consumer engagement. Therefore, it recommends implementing targeted awareness campaigns and advocates for a more nuanced and context-specific approach to global initiatives.

## Conclusion

Plastic waste presents a significant challenge to supply chains worldwide, necessitating coordinated action from all stakeholders. This study contributes to both the theoretical and practical aspects of supply chain management by presenting a dynamic recalibration model that considers the fluidity of the global economic and technological landscapes. The theoretical value of this study lies in introducing a nuanced framework that identifies emerging variables that influence plastic pollution and integrates them into existing sustainability strategies. Practically, this study offers empirically derived insights that enable practitioners to implement adaptive evidence-based approaches for reducing plastic waste. The recalibration model goes beyond static solutions, advocating for iterative assessments and swift responsiveness to new data and global trends, thus enriching the strategic toolkit available for supply chain managers to confront the multifaceted challenges of plastic pollution. This study identifies crucial areas that require further investigation to effectively combat plastic pollution in GSCs. Previous studies have explored economic measures, such as plastic taxes and EPR systems, but a comprehensive examination of their long-term consequences is lacking. Future research should assess the potential economic benefits and losses of sustainable practices and the economic feasibility of biodegradable alternatives. Although previous studies have focussed on alternatives to conventional plastics, detailed studies are required to evaluate their environmental impact, durability, and recyclability. This study also emphasises the role of consumer behaviour in plastic pollution. However, there is a lack of research on ways to encourage sustainable choices among consumers. Future studies should explore strategies to promote the principles of reduction, reuse, and recycling among consumers. Although international

frameworks aimed at reducing plastic pollution have been studied, research evaluating their effectiveness is scarce. Future studies should assess the impact of these policies and identify best practices. Multidisciplinary research that integrates insights from economics, materials science, and other relevant fields is necessary to effectively address the complex problem of plastic pollution.

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### Authors' contributions

Both authors, A.M and N.F., contributed equally to the work. A.M. contributed to the conceptualisation, research and structure of the paper and was instrumental in shaping the narrative and arguments presented in the article. N.F. played a crucial role in the research and writing process and synthesis of information.

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This article followed all ethical standards for research without direct contact with human or animal subjects.

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The data that support the findings of this study are available on request from the corresponding author, A.M.

### Disclaimer

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