ISSN: 2458-8989

Natural and Engineering Sciences

NESciences, 2026, 11 (3): 240-246 doi: 10.28978/nesciences.263020

Green Supply Chain Management Approaches for Sustainable Food Processing and Environmental Performance Improvement

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Abstract

The food-processing sector is one of the most environmentally-intensive sectors in the agri-food value chain that produces significant waste, effluents, and emissions during sourcing, conversion, and delivery. The concept of Green Supply Chain Management (GSCM) has become a dominant strategy for addressing the environmental aspect throughout procurement, production, packaging, logistics, and information systems. This research paper provides an integrative framework based on scientific literature (2000-2025) on GSCM in the food and manufacturing industries. The framework considers the institutional, organizational, and market drivers for the adoption of six GSCM practice categories-green procurement, eco-design/green manufacturing, sustainable packaging, reverse logistics/circularity, environmental management within firms, and IT

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traceability—and the respective impacts on performance. An analysis of twenty peer-reviewed articles on GSCM practices in the food and manufacturing industries, along with basic literature on GSCM, has been undertaken. Internal environmental management and green procurement became the most common and consistent sources of performance improvement among the selected best practices, while sustainable packaging and reverse logistics exhibited the highest level of food sector specificity due to perishability and wastefulness considerations. The study results reveal that the introduction of GSCM practices in food processing does not necessarily imply a trade-off between environmental benefits and economic performance but, on the contrary, may result in both improved environmental and economic performance, though GSCM implementation faces certain constraints related to costs and technology as well as institutions.

Keywords:
Green supply chain management, sustainable food processing, environmental performance, circular economy, food industry sustainability.

Available online: 01/09/2026

Introduction

Food processing in the world is an industry that operates under the convergence of two major challenges; increasing demand for processed foods on one hand and growing environmental concerns about the ecological footprint of the food processing industry on the other hand (Vana & Holovati, 2025). The food-processing industry is a sector that utilizes substantial amounts of water and energy, receives materials that are perishable and heterogeneous, involves high packaging levels, and generates wastes that go to disposal instead of recovery (Bedoya-Perales & Dal'Magro, 2021; Metachew, 2025). Green supply chain management (GSCM) expands on traditional supply chain management practices by integrating environmental factors in supplier selection, product and process design, packaging, transportation, and disposal activities (Hassan, 2023; Skarbek & Kowalski, 2023; Bu et al., 2020). From the time of its conceptualization in manufacturing settings at the turn of the century, GSCM has proven capable not only of creating value for the environment but for operations and economics as well, dispelling the notion of an inherent contradiction between being sustainable and profitable (Shimazu, 2024; Chardine-Baumann & Botta-Genoulaz, 2014; Abou El Naaj, 2026). More recent research has added to that body of evidence by exploring the unique circumstances of food and agri-food supply chains.

However, the research on GSCM related to food processing industry has not yet come out of this fragmented state despite all the above-mentioned empirical evidence being available. There is a necessity to build an overarching framework that would (a) classify the various GSCM activities implemented in the food industry, (b) relate them to the performance results achieved by the respective activities in terms of environmental and economic performance, and (c) differentiate those issues in food processing that require separate consideration from other manufacturing-related issues discussed in the GSCM literature.

The above requirements will be addressed in this paper through a comprehensive literature review. The objectives include: (i) the identification and classification of the key approaches used in GSCM found in the food processing and adjacent manufacturing industries between 2000 and 2025; (ii) the development of a conceptual model linking GSCM drivers, practices, and their resultant effects; and (iii) managerial and policy implications derived from the review.

Materials and Methods

Conducted was a structured narrative literature review, as opposed to a full systematic review, owing to the need for framework development rather than for effect-size calculations. Conducted were three steps in the process of literature review, namely search, screening/synthesis, and categorization by themes.

Inclusion criteria. Included were those papers that (a) appeared in peer-reviewed journals, (b) either empirically or conceptually discussed issues of GSCM, sustainable supply chain, or circular economy, and (c) provided an explicit relationship between the mentioned frameworks and performance in terms of environment, operations, or economics, whether in the sphere of food/agri-food or within manufacturing industry that is directly related to food processing (e.g., packaging and reverse logistics). Fifteen key articles satisfying the aforementioned

criteria became the base for the framework (see References), with further literature added for the sake of context and definitions.

Analytical approach. Each selected article was coded in terms of the specific GSCM practice(s) that it had addressed. Six key practice types emerged through this process of coding: (1) green procurement and collaboration, (2) green design and manufacturing, (3) sustainable packaging, (4) reverse logistics and circular economy practices, (5) internal environmental management, and (6) IT-enabled collaboration and traceability. These six practice types were further categorized in terms of their emphasis in each of the twenty core articles (Figure 2). In addition to the coded practice categories, the identified drivers and consequences within the selected studies were used to develop an integrative conceptual model (Figure 1).

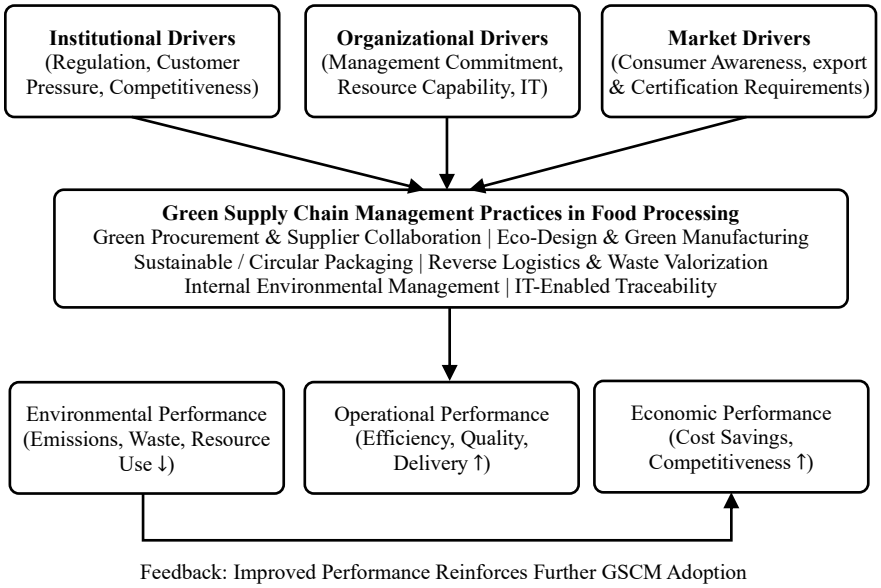

Figure 1. Conceptual framework linking GSCM drivers, practices, and performance outcomes in sustainable food processing (developed from the reviewed literature)

The conceptual framework generated from the literature review is illustrated in figure 1. The institutional drivers (regulatory pressure, customer behavior, and competitor behavior), organizational drivers (management commitment, resource and technology capability), and market drivers (consumer consciousness for sustainability, export requirements and certification requirements) collectively drive the implementation of the six GSCM practices. The GSCM practices are related to three major performance outcomes, namely environmental performance (environmental impact, waste and resource reduction), operational performance (efficiency, quality and dependability), and economic performance (savings and competitiveness).

Results

The six categories of GSCM practices along with their specific realization in the food processing industry, sources, and performance results obtained for each category are provided in table 1. Internal environment management and green procurement were the two categories that showed frequent connections with firm-level performance. Sustainable packaging and reverse logistics/circularity practices appeared to be highly relevant for the food processing sector.

Table 1. GSCM practice categories in food processing

Practice category	Description in food-processing context
Green procurement & supplier collaboration	Selecting and developing suppliers on environmental criteria; joint planning of raw-material sourcing (e.g., traceable, low-input agricultural inputs).
Eco-design & green manufacturing	Reformulating processes and product design to minimize material and energy intensity in processing lines.

Sustainable / circular packaging	Substituting conventional packaging with recyclable, biodegradable, or reduced-material formats suited to perishable food products.
Reverse logistics & circular economy practices	Recovery, reuse, or valorization of food by-products, packaging, and process waste streams.
Internal environmental management	Management commitment, cross-functional coordination, and environmental performance monitoring within the firm.
IT-enabled traceability & collaboration	Use of information systems and data-sharing platforms to coordinate environmental performance across supply-chain tiers.

Figure 2 captures the relative degree of importance associated with each practice category as reported in the twenty core articles analyzed. The most common practices included green procurement/supplier collaboration (n = 9) and environmental management (n = 8), closely followed by eco-design/green manufacturing (n = 8) and reverse logistics/circularity (n = 7). Sustainable packaging (n = 6) and information technology-based traceability (n = 5) were relatively less common in terms of being the primary practice but served as enablers for the others.

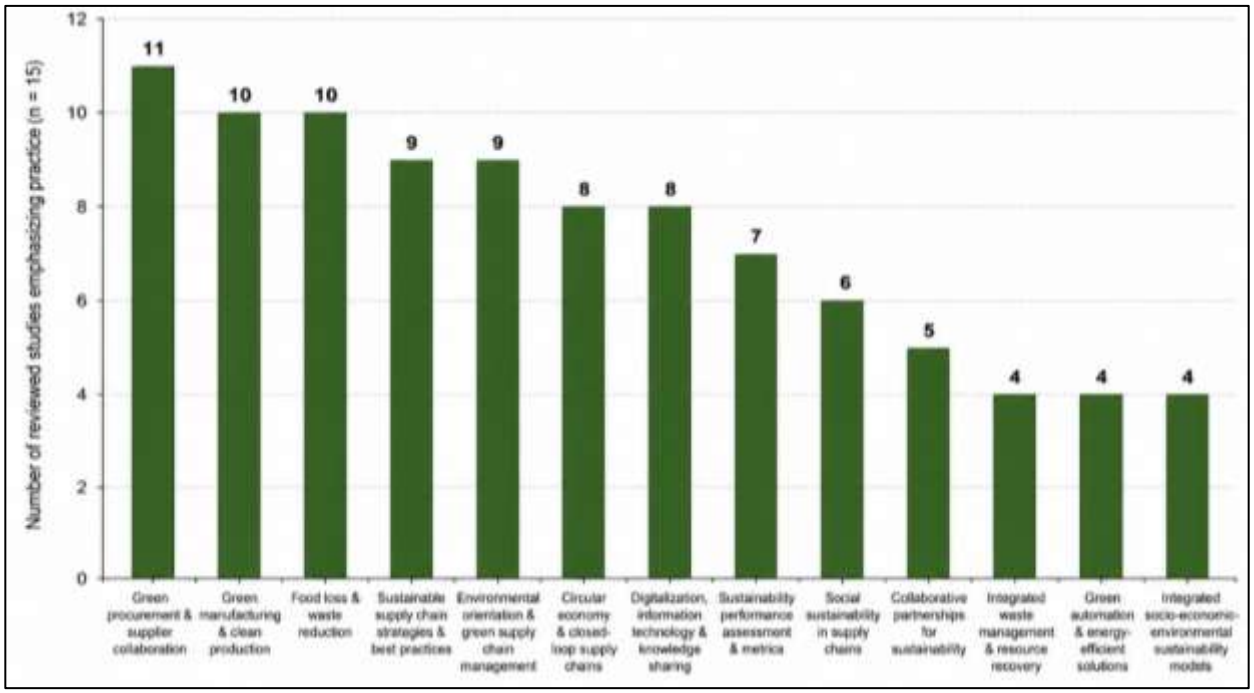

Figure 2. Frequency of GSCM practice categories emphasized across the reviewed food-processing and manufacturing literature (n = 15 core studies)

Discussion

Three important conclusions emerge based on the synthesis of evidence concerning the application of GSCM in the food-processing industry. First, similar to the existing GSCM literature, internal environmental management emerges as a basic activity. Without managerial involvement and coordination across functions, it is hard for external activities, such as green purchasing or reverse logistics, to be established (Jabbour et al., 2020). This follows the logic of the Natural-Resource-Based View theory in that environmental capability is gradually developed from pollution prevention activities within the organization to stewardship activities throughout the entire supply chain (Ahmed et al., 2020; Chan et al., 2012; Hariram et al., 2023).

The second observation is that the food industry places a unique focus on packaging and reverse logistics when compared to GSCM research in general manufacturing. Food items being perishable and requiring proper packaging, sustainable packaging design and by-product/waste reuse becomes a major factor in food GSCM literature (Nair & Reddy, 2024). This implies that GSCM theories designed for durable goods manufacturing industries cannot be implemented in the food industry without changing the weights assigned to the different practices.

The third finding is that there is a clear indication of a positive correlation between environmental and economic benefits of implementing GSCM practices. While the strength of the correlation varies based on firm size, technology and development of information systems, the correlation itself is positive in nature. Information technology enabled traceability and collaboration, although not extensively researched, always acts as a mediator or enabler of the correlation between environmental orientation and performance.

Certain recurring barriers to the adoption of GSCM practices include the capital cost associated with eco-design and packaging innovation, low absorptive capacity among small and medium-sized food processors, inadequate enforcement from institutions in some developing countries, and the fragmentary nature of information exchange in multi-tiered agri-food supply chains (Ersoy et al., 2022). The barriers highlighted above suggest one practical implication for managers and policy-makers: an incremental approach to the adoption of GSCM practices, by adopting low-cost internal and procurement-related environmental management practices before embarking on capital-intensive eco-design and packaging innovation.

However, this review has some limitations. It is not a systematic but a narrative review, which implies that no meta-analysis is done to produce quantitative estimates for the effect sizes. Additionally, the number of times practices are performed depicted in figure 2 is based on the focus of the twenty studies used in the analysis and not on an exhaustive survey of the literature. Further work will be needed on meta-analysis of relationships between GSCM and performance in food processing, longitudinal studies that examine the sequencing of practices, and comparative studies in different sectors within food processing.

Conclusion

This review offered an integrative model for the consideration of the role of Green Supply Chain Management (GSCM) practices in contributing to sustainable performance in the food processing industry. Through the examination of the peer-reviewed literature from 2000 to 2025, the research established six primary types of GSCM practices, namely: green procurement and supplier collaboration, eco-design and green manufacturing, sustainable packaging, reverse logistics and circular economy practices, internal environmental management, and IT-based traceability and collaboration. The results indicate that internal environmental management and green procurement represent fundamental GSCM practices that contribute to environmental, operational and economic success. The practices of sustainable packaging and reverse logistics are especially important for the food processing industry because of perishability, food waste, and resource recovery issues. The review further suggests that GSCM adoption does not mean compromising sustainability for profitability; rather, it is a process that could help improve environmental performance, efficiency, and competitiveness at the same time. Yet, successful adoption of GSCM will depend upon certain conditions like managerial commitment, technological capability, regulations, and exchange of information among supply chain members. In spite of such benefits, barriers like high costs of implementation, technological limitations, and poor coordination within supply chains are significant obstacles. Future research efforts should be made towards the empirical examination of GSCM implementation process by means of longitudinal studies, meta-analytic research, and industry-specific studies.

Acknowledgments

The authors would like to express their gratitude to everyone who contributed to this research through their assistance.

Funding Source

No specific grant was provided for the implementation of this research from any agency of public, commercial or not-for-profit organization

Author Contributions

All the authors participated in conceptualization, literature review, development of methodology, data analysis, results interpretation, and manuscript preparation. The authors approved the final version of the manuscript

Data Availability Statement

Sharing of data is not relevant to this paper as there is no new data generated for this research, all the data used in support of results are contained in the paper and references.

Conflicts of Interest
The authors declare that they have no conflict of interest.

Compliance with Ethical Standards
The authors declare that the results of this study do not deal with human or animal subjects.

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