Portuguese Journal of Finance, Management and Accounting

ISSN: 2183-3826. Vol 12, Nº 23, March 2026

PJFMA

From Practices to Performance: A Triple Bottom Line Framework for Sustainable Warehouse.

Das Práticas ao Desempenho: Um Quadro de Triplo Resultado para Armazém Sustentável.

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Abstract

Purpose: This study aims to propose a comprehensive framework to support sustainability in warehousing operations by identifying key improvement areas and practices, enabling self-assessment and continuous improvement from a Triple Bottom Line (TBL) perspective.

Design/methodology/approach: A narrative literature review was conducted and complemented with thematic analysis to identify and compare existing sustainable warehousing models and frameworks. Based on a comparative synthesis of the literature, a conceptual framework was developed to integrate the main sustainability areas relevant to warehousing operations.

Findings: The literature reveals a growing interest in sustainable warehousing; however, research remains limited and fragmented, with few comprehensive frameworks integrating environmental, social, and economic dimensions. The proposed framework consolidates a comprehensive set of key areas and systematically integrates diverse sustainable practices and concrete actions, mapping their expected impacts across environmental, social, and economic performance. Additionally, it highlights two frequently overlooked areas, collaboration with supply chain partners and community engagement, thereby extending sustainability efforts beyond warehouse boundaries.

Research limitations/implications: This study is conceptual in nature and based on a narrative review, and the proposed framework has not yet been empirically validated. Future research should apply and test the framework in different contexts, including Portuguese companies, to assess its effects on TBL performance.

Originality/value: This study contributes by proposing an integrated and practical framework to guide sustainable warehousing initiatives, supporting decision-makers in identifying priority areas and implementing improvement actions aligned with TBL principles.

Keywords: Warehousing, Sustainability, Framework, Triple Bottom Line, Logistics.

Paper Type: Conceptual paper.

Received on: 2026.01.25

Approved on: 2026.03.23

Evaluated by a double blind review system

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1. INTRODUCTION

Sustainability challenges such as climate change, pollution, increased waste generation, biodiversity loss, and deforestation require coordinated efforts from multiple stakeholders. In response, many countries have committed to achieving carbon neutrality, reducing greenhouse gas emissions, and mitigating global warming (Fan et al., 2022; Wei et al., 2022). As a result, companies are increasingly pressured by governments, regulators, customers, investors, and society to integrate sustainability objectives into their operations and supply chains.

The literature highlights that the adoption of sustainable practices can generate not only environmental and social benefits but also economic advantages. For example, Ramaa et al. (2012) emphasize the importance of implementing environmental practices in supply chain and logistics operations, noting that improvements in operational performance can significantly contribute to the reduction of CO_2 emissions. Indeed, a significant share of global greenhouse gas emissions originates from major supply chains such as fast-moving consumer goods, food, fashion, electronics, professional services, construction and automotive, and freight transport (Bataille et al., 2020).

In this context, warehouses and warehousing operations play a critical role in supply chains and logistics strategies, generating significant sustainability impacts due to their intensive use of energy and other resources (Centobelli et al., 2017; Freis et al., 2016). Warehousing operations account for approximately 24% of logistics costs, while logistics buildings alone are responsible for about 10% of total CO_2 emissions in the logistics and transport sectors (Doherty et al., 2009).

Despite the growing importance of sustainability in logistics, research on sustainable warehousing remains relatively limited. Several studies highlight the need for further investigation into sustainability practices within warehousing operations. For example, Torabizadeh et al. (2020) note the lack of comprehensive research addressing sustainability in warehouse management systems. Similarly, Minashkina and Happonen (2023) emphasize the limited number of studies on WMS that address the issue of sustainability. Other researchers also point to the need for further investigation into the environmental impacts of warehousing operations (Ries et al., 2017; Xin et al., 2019).

Although the number of studies on sustainable warehousing has increased in recent years, the literature remains fragmented and calls for more comprehensive frameworks and empirical research in this area (Al-Saad et al., 2023; Bartolini et al., 2019).

Consequently, this study aims to propose a conceptual framework for sustainable warehousing, grounded in a TBL perspective. The TBL approach integrates environmental, social, and economic dimensions and is widely recognized as one of the most comprehensive perspectives for incorporating sustainability into organizational decision-making (He et al., 2017). Based on a literature review, the framework identifies key areas for improvement and sustainable practices in warehouses and warehousing operations. It is intended to support organizations in assessing their current practices and guiding the implementation of sustainability initiatives within warehouse management and across supply chains.

2. THEORETICAL FRAMEWORK

Warehousing encompasses a range of activities, including receiving, put-away, storage, sorting, material handling, picking, and packing, supported by various equipment and automotive tools for material storage, along with the necessary building facilities to safeguard goods (Saderova et al., 2020). Over time, the role of warehouses has evolved beyond traditional storage functions to include activities such as manufacturing, assembly, reverse logistics, and other value-added services. As supply chains become more complex and integrated, warehouses increasingly play a strategic role in logistics systems.

Growing attention to environmental and social concerns within supply chain operations has led to the emergence of the concepts of *sustainable warehouse* and *sustainable warehousing*, which are often used interchangeably in the literature. Żuchowski (2015) defines a sustainable warehouse as "a set of organizational and technological solutions whose aim is to efficiently execute warehouse processes, with the highest social standards met, with the lowest possible environmental impact and taking financial effectiveness into account". According to Malinowska (2019), this definition encompasses different dimensions of sustainability, including building design, the application of advanced technologies to support warehouse processes, and the application of social policies aimed

at ensuring higher standards of work. As such, sustainable warehousing inherently reflects a TBL perspective, which integrates environmental, social, and economic dimensions of organizational performance.

The environmental and social impacts associated with warehousing operations have grown considerably in recent years (Perotti et al., 2023). Consequently, improving sustainability practices in warehousing operations has significant potential to enhance overall sustainability performance. For example, Burinskien et al. (2018) demonstrate that optimizing internal transport and forklift operations can reduce warehouse waste by nearly 60%, contributing to environmental sustainability. Ries et al. (2017) highlight the role of technologies such as warehouse management systems (WMS) in reducing carbon emissions and improving operational efficiency. Minashkina and Happonen (2023) conclude, through a systematic literature review examining the relationship between WMS and sustainability, that the use of WMS functionalities and their integration into operations management positively contributes to both social and environmental sustainability.

While technological and operational improvements are critical, sustainability in warehousing is also shaped by broader institutional and stakeholder pressures. Increasingly stringent environmental regulations, sustainability policies, and international agreements are influencing logistics and supply chain practices. At the same time, growing expectations from investors, consumers, the media, and society at large, are placing sustainability at the forefront of organizational decision-making (Perotti et al., 2023).

Within this context, Stakeholder Theory provides an important theoretical lens for understanding how sustainability initiatives are adopted and implemented in logistics and warehousing operations. According to Stakeholder Theory, organizations must consider and respond to the expectations and interests of multiple stakeholders who can influence or be affected by organizational activities (Freeman, 1984; Parmar et al., 2010). In logistics and supply chain contexts, stakeholders such as regulators, customers, employees, supply chain partners, and local communities increasingly demand more sustainable operational practices.

Recent studies have increasingly used Stakeholder Theory to explain the adoption of sustainable practices in logistics and warehousing operations. For example, Yoo et al. (2025) have shown that stakeholder pressures significantly influence the implementation of environmental and social practices in logistics organizations, including energy efficiency initiatives, emission reduction strategies, and responsible operational practices. Ifekanandu et al. (2025), in a study examining the adoption of sustainable energy and fuel solutions in logistics operations, highlight the role of regulatory pressures, customer demand, and supplier collaboration in encouraging companies to implement sustainability-oriented practices. Other research emphasizes that sustainability initiatives in logistics systems frequently emerge from the coordination and collaboration between multiple stakeholders, whose interests and pressures influence organizational responses to environmental challenges and stimulate the adoption of green logistics practices (Bálint et al., 2025). In warehousing operations specifically, research highlighted that both internal stakeholders (e.g., managers and employees) and external stakeholders (e.g., customers, regulators, suppliers, and local communities) play a critical role in shaping sustainability strategies and practices (Wahab et al., 2018; Modica et al., 2021). These stakeholders influence the adoption of initiatives aimed at reducing environmental impacts, energy efficiency, occupational health and safety, and socially responsible operational practices. Consequently, Stakeholder Theory provides the conceptual foundation for the architecture of the framework proposed in this study, recognizing that sustainability practices within warehouses are not only driven by internal operational improvements but also by the expectations, pressures, and collaborations arising from multiple stakeholder groups.

In addition to examining the factors that can facilitate the transition to sustainability, it is essential to identify the key operational areas and practices through which sustainability can be implemented in warehousing operations. The literature provides several examples of models and frameworks aimed at identifying such critical elements. However, existing frameworks often address only specific dimensions of sustainability or focus on particular operational aspects of warehouse management. There remains a lack of comprehensive frameworks capable of integrating the various operational areas of warehouse management within a holistic Triple Bottom Line perspective. Developing such a

framework can provide valuable guidance for both researchers and practitioners seeking to implement sustainability practices within warehousing operations.

3. METHODOLOGY

This study adopts a narrative literature review as the primary methodological approach. Narrative reviews are particularly suitable for emerging or fragmented research domains, as they allow researchers to synthesize a broad body of knowledge, integrate diverse theoretical perspectives, and provide a comprehensive understanding of how a topic has been conceptualized and discussed in the literature (Snyder, 2019). In the context of sustainable warehousing, research remains dispersed across different conceptual perspectives and operational domains, and existing proposals vary substantially in terms of scope and sustainability dimensions. Therefore, a narrative approach is appropriate to capture this diversity and to support the development of an integrative and practice-oriented framework.

Although the study adopts a narrative literature review approach, the search and selection of publications followed a structured process to ensure transparency and replicability. To improve methodological transparency, the narrative literature review used a structured search strategy based on established guidelines. Although narrative reviews are more flexible than systematic reviews, several authors recommend adopting transparent procedures for the search strategy, selection criteria, and analytical synthesis to enhance rigor and replicability (Snyder, 2019; Tranfield et al., 2003).

The process comprised five main stages: identification, screening, eligibility assessment, thematic analysis and synthesis (Figure 1).

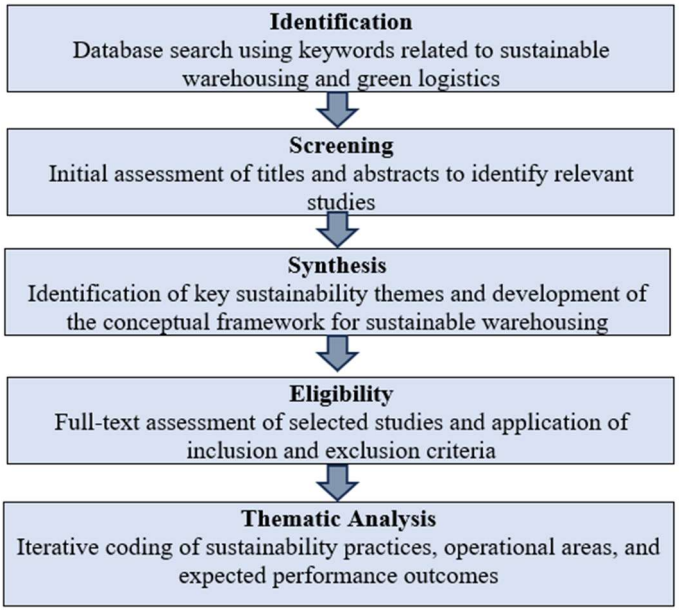

Figure 1 - *Methodological process adopted*

Source: Adapted from Tranfield et al. (2003), Snyder (2019), and Braun & Clarke (2006).

In the identification stage, publications were retrieved from the Scopus and Web of Science databases, as well as through the B-On (Online Knowledge Library) platform, which provides access to a wide range of publications in logistics, operations management, and sustainability research. The search strategy combined several keywords related to sustainability and warehousing operations, including: "sustainable warehousing", "green warehouse", "warehouse sustainability", "green logistics", "sustainable logistics operations", and "warehouse management systems sustainability". Boolean operators (AND, OR) were applied to combine search terms to broaden coverage while maintaining relevance.

The search focused primarily on peer-reviewed journal articles, conference proceedings, and academic studies published between 2010 and 2024. This time horizon was selected because research on sustainable warehousing has expanded considerably over the past decade, particularly following the broader development of sustainable supply chain management literature (Perotti & Colicchia, 2023).

During the screening stage, duplicate records were removed, and titles and abstracts were examined to exclude studies not directly related to warehousing operations and sustainability. Studies were included when they addressed sustainability practices in warehouses, indicators, technologies, or frameworks, models and management approaches directly related to warehousing operations and sustainability.

The eligibility stage involved a full-text review of the remaining articles to assess their relevance to the research objective. Studies focusing exclusively on transportation or broader supply chain sustainability without explicit implications for warehousing were excluded.

After this process, the final sample included 32 articles, which were analyzed through thematic coding and synthesis. Thematic analysis is particularly appropriate in emerging research domains characterized by conceptual fragmentation and methodological heterogeneity. In such contexts, narrative reviews complemented by thematic analysis allow researchers to integrate dispersed contributions and develop conceptual frameworks that capture the multidimensional nature of sustainability practices (Snyder, 2019; Tranfield et al., 2003).

Similar methodological approaches have been adopted in several studies within logistics and supply chain management research (e.g., Silva et al., 2023; Ren et al., 2019). Building on this methodological tradition, the thematic synthesis conducted in this study enabled the integration of diverse contributions from sustainable warehousing literature and supported the development of the conceptual framework proposed in this research. By organizing sustainability practices into coherent operational areas and linking them to environmental, social, and economic outcomes, the framework provides a structured basis for analyzing sustainability initiatives within warehousing operations.

In this study, each selected publication was carefully reviewed in order to extract sustainability practices, operational domains, and expected performance outcomes discussed in the sustainable warehousing literature. Following established approaches for literature-based theory development (Tranfield et al., 2003; Snyder, 2019), the analysis was conducted using an iterative thematic coding process (Braun & Clarke, 2006). During this process, the studies were carefully examined, and sustainability-related practices

associated with warehouse management and logistics operations were identified and coded. Through repeated reading and comparison of the selected publications, similar practices and concepts were grouped into broader thematic categories according to their operational focus and their expected sustainability outcomes. This analytical procedure enabled the identification of recurring operational themes across literature. The identified practices were subsequently consolidated into key operational areas including infrastructure, energy, water management, waste management, human resources, material handling equipment, warehouse processes, layout design, inventory management, transport activities, and external collaboration. The resulting thematic categories provided the analytical basis for comparing the different conceptual models and frameworks proposed in previous studies. By examining the convergence and divergence among these frameworks, it was possible to consolidate fragmented contributions from the literature into a coherent analytical structure grounded in the TBL perspective. This structured synthesis ultimately supported the development of the conceptual framework proposed in this study. The sustainability areas identified through this process are discussed in the following section, together with the comparative analysis of existing frameworks.

4. RESULTS

This section presents the results of the literature synthesis and the development of the proposed framework. First, the main sustainable warehousing frameworks identified in the literature are reviewed to illustrate the diversity of approaches adopted in previous studies. Second, the analysis identifies the key operational areas that are consistently associated with sustainable warehousing practices. Third, the conceptual framework proposed in this study is presented and discussed. Finally, examples of sustainability practices and their expected impacts on environmental, social, and economic performance are described to illustrate how warehouse initiatives can influence Triple Bottom Line outcomes.

The literature review indicates that several studies have proposed models and frameworks addressing sustainability in warehousing operations. Table 1 summarizes representative frameworks identified in the literature and illustrates the diversity of approaches adopted to integrate sustainability into warehouse management.

Table 1 - *Examples of frameworks for sustainable warehousing*

Authors (date)	Areas/model constructs	Sustainability dimensions		
		Envir.	Soc.	Econ.
Ali et al. (2023)	Employee green training; Green transport; Green operation; Green waste; Green strategies; Green culture; Green control measures; Green building	✓		
Vasileva et al. (2022)	Smart warehousing; Green warehousing; Optimization; Safety	✓	✓	✓
Torabizadeh et al. (2020)	Warehouse performance operations, Economy performance, Resources, Emission waste and environment commitment, Labor practice and decent work; Product responsibility and society	✓	✓	✓
Malinowska et al. (2018)	Level of automation; Green lean practices; Employee training; Resources and Energy Consumption	✓	✓	✓
Amjed & Harrison (2013)	Warehouse Design; Warehouse Layout; Inventory Management; Warehouse Staff; Mechanical Handling Equipment; Warehouse Processes; On-site Facilities; Warehouse Management System	✓	✓	✓
Mulder (2013)	Heating; Lighting; Water; Energy; Waste	✓		
Marchant (2010)	Energy; Water and land; Building materials	✓	✓	✓

Source: Author elaboration (2026).

These frameworks differ in terms of the sustainability themes addressed, the operational practices considered, and the environmental, social, and economic impacts associated with the TBL perspective. While some frameworks primarily emphasize environmental initiatives such as energy efficiency, resource management, and green building design (Mulder, 2013; Marchant, 2010), others focus more strongly on operational practices and technological solutions related to warehouse management and logistics processes (Amjed & Harrison, 2013; Torabizadeh et al., 2020). For instance, Marchant (2010) introduced a three-stage sustainable warehouse model that encompasses the economic, environmental, and social dimensions of warehousing. This model follows a systems approach and aims to broaden the criteria for organizations to minimize their negative sustainability impact. Malinowska et al. (2018) proposed a model comprising 22 warehouse activities designed to enhance sustainability performance, categorized under Building Design, Warehouse Equipment, and Human Policy. The authors indicate directions and changes in technological, managerial, social, environmental, and economic aspects of warehouse functioning that are required to progress towards a sustainable tendency. Amjed and Harrison (2013) developed a comprehensive model consisting of eight sustainable

warehousing constructs (Warehouse Design; Warehouse Layout; Inventory Management; Warehouse Staff; Mechanical Handling Equipment; Warehouse Processes; On-site Facilities; and Warehouse Management System), operationalized through activities associated with different sustainability dimensions. The authors also recommended 30 best practice activities to serve as a guide for setting future sustainability targets and goals. Furthermore, Ali et al. (2022) underscored the significance of integrating sustainable initiatives for positive outcomes. They presented a framework focused on green warehouse practices to measure sustainability performance. Torabizadeh et al. (2020) suggest a comprehensive set of key indicators for a warehouse to assess sustainability performance considering a TBL approach. These indicators are associated with several areas: Warehouse performance operations; Economic performance; Resources; Emission waste and environmental commitment; Labor practice and decent Work; and Product responsibility and society. Mulder (2013) presented a multi-criteria analysis listing more than 20 recommended options, like dynamic lighting with motion sensors, a wind turbine, PV panels, etc. for sustainable warehousing. More recently, Vasileva et al. (2022) analyze the main criteria to consider in the transition from conventional storage to sustainable storage, defining the following areas: smart warehousing, green warehousing, optimization, and safety.

Taken together, the frameworks summarized in Table 1 illustrate the diversity of perspectives adopted in the literature and highlight the absence of a comprehensive model integrating the various operational areas of warehouse management within a unified sustainability framework.

The comparative analysis of the frameworks reveals several recurring operational areas consistently associated with sustainable warehousing practices. These include infrastructure and building design, energy management, waste reduction, warehouse processes, human resource practices, and technological solutions such as warehouse management systems and automation (Amjed & Harrison, 2013; Malinowska et al., 2018; Torabizadeh et al., 2020; Perotti & Colicchia, 2023). These recurring themes provided the analytical basis for identifying the key operational areas through which warehouse activities can influence sustainability performance. However, the analysis also indicates that existing frameworks often focus on specific aspects of sustainability rather than

adopting a holistic perspective. Some models emphasize environmental initiatives, while others concentrate on operational efficiency or technological solutions.

As a result, the literature remains fragmented, with relatively few frameworks addressing sustainability in warehouses in an integrated manner that simultaneously considers environmental, social, and economic dimensions.

Building on the synthesis of the literature, the framework proposed in this study adopts a more integrative perspective by combining a comprehensive set of operational areas with a TBL approach and an explicit stakeholder-oriented perspective.

Accordingly, the framework encompasses key areas related to infrastructure, energy, water management, waste management, human resources, mechanical equipment, warehouse processes, layout design, inventory management, transport activities, collaboration with supply chain partners, and community engagement.

The selection and consolidation of these areas were guided by two main criteria. First, the areas needed to capture the principal operational dimensions of warehouse management identified in the literature. Second, they needed to reflect the multidimensional nature of sustainability as conceptualized by the TBL framework, which emphasizes the simultaneous consideration of environmental, social, and economic performance (Elkington, 1997; Carter & Rogers, 2008).

In addition to the TBL perspective, the framework is conceptually informed by Stakeholder Theory, which highlights the influence of multiple stakeholders (such as employees, customers, regulators, supply chain partners, and local communities) on the adoption of sustainability initiatives in logistics systems (Freeman, 1984; Parmar et al., 2010). In the context of warehousing operations, sustainability initiatives are increasingly influenced by regulatory pressures, environmental policies, market expectations, and community concerns (Perotti et al., 2023). Consequently, stakeholder demands may shape the adoption of practices related to energy efficiency, environmental impact reduction, employee well-being, and socially responsible operations.

Figure 2 presents the proposed framework, illustrating the role of stakeholders in integrating sustainability objectives into warehousing operations and identifying the key

operational areas through which sustainability practices can influence Triple Bottom Line performance.

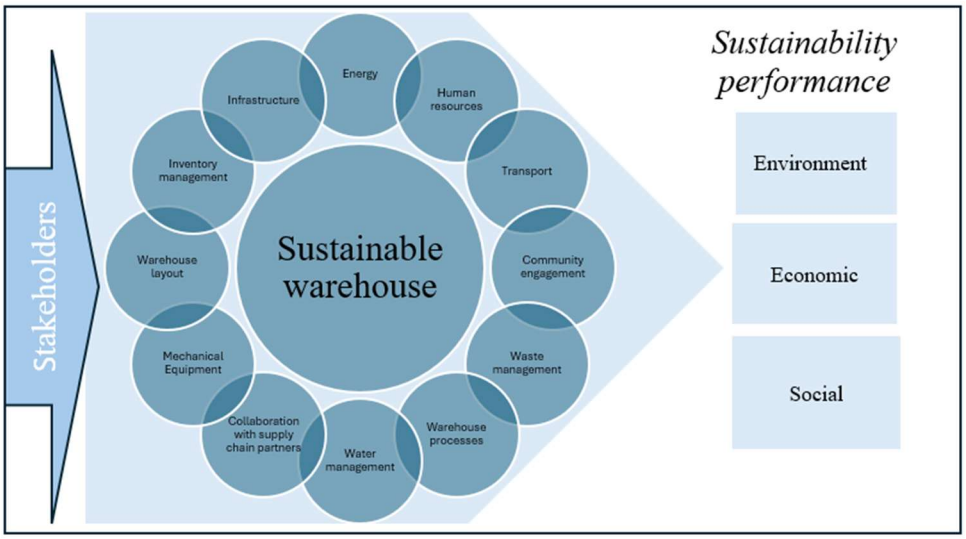

Figure 2 - *Framework for a sustainable warehouse*

Source: Author elaboration (2026).

To illustrate the relationship between warehouse sustainability practices and their performance outcomes, Table 2 presents examples of practices associated with each operational area and their expected impacts across the TBL dimensions. These relationships between operational practices and sustainability performance outcomes were identified through the literature review conducted in this study. Examples of additional practices, specific actions, and their corresponding impacts are available at https://figshare.com/s/5063fcd52316855039e6C.

Table 2. Warehouse sustainability practices and expected impacts on Triple Bottom Line performance

Key area	Examples of sustainability practices	Environmental performance impacts	Social performance impacts	Economic performance impacts
Infrastructure	Environmentally friendly construction materials; Green roofs; Natural lighting; Improved insulation	Reduced energy consumption and greenhouse gas emissions	Improved indoor environmental quality and working conditions	Lower energy costs and increased building efficiency

Energy	Renewable energy systems; LED lighting; Motion sensors; Energy monitoring systems	Reduced electricity consumption and carbon emissions	Improved workplace safety and lighting conditions	Reduced operational energy costs
Water management	Rainwater harvesting; Water reuse systems; Efficient water fixtures	Reduced water consumption and resource use	Improved environmental responsibility and regulatory compliance	Lower water supply costs
Waste management	Recycling programs; Reusable packaging; Reduction of paper-based processes	Reduced waste generation and improved resource efficiency	Increased environmental awareness among employees	Reduced disposal and material costs
Human resources	Training in sustainable practices; Occupational health and safety policies; Ergonomic workplaces	Improved environmentally responsible behavior	Improved employee well-being, safety, and job satisfaction	Increased productivity and reduced accident-related costs
Mechanical equipment	Electric forklifts; Automated handling systems; Preventive maintenance programs	Reduced emissions and energy consumption	Safer working environment	Increased operational efficiency and lower maintenance costs
Warehouse processes	Route optimization; Quality control procedures; Reduction of non-value-added activities	Reduced resource consumption and operational waste	Improved operational safety and workflow organization	Increased operational efficiency and cost reduction
Warehouse layout	Optimized storage layout; Reduced travel distances; Efficient picking zones	Lower energy use for internal transport	Improved worker ergonomics and safety	Reduced handling time and operational costs
Inventory management	Accurate inventory control; Optimized stock levels; Improved space utilization	Reduced waste and resource use	Improved workflow coordination	Reduced storage costs and improved service levels
Transport	Low-emission transport vehicles; Driver training for eco-efficient driving	Reduced air pollution and fuel consumption	Improved driver safety	Lower fuel costs and improved logistics efficiency
Collaboration with supply chain partners	Reverse logistics practices; Returnable transport packaging; Information sharing	Reduced packaging waste and emissions across the supply chain	Stronger cooperation and knowledge sharing among partners	Cost savings through coordination and resource efficiency
Community engagement	Support for local suppliers; Community sustainability initiatives; Environmental awareness programs	Improved local environmental outcomes	Enhanced community relations and social responsibility	Strengthened corporate reputation and local economic benefits

Source: Author elaboration (2026).

Previous research demonstrates that specific warehouse practices can simultaneously influence multiple sustainability dimensions. For example, practices related to infrastructure and energy management, such as the use of environmentally friendly construction materials, improved insulation, renewable energy systems, and energy-efficient lighting, can significantly reduce energy consumption and carbon emissions while improving working conditions and lowering operational costs. Similarly, initiatives associated with warehouse processes and layout design, including route optimization and efficient storage configurations, can reduce resource consumption, improve worker ergonomics and safety, and enhance operational efficiency (Freis et al., 2016; Centobelli et al., 2017; Perotti & Colicchia, 2023).

Other areas also demonstrate clear links between operational practices and sustainability outcomes. For instance, human resource practices, such as training in sustainable operations and the implementation of occupational health and safety policies, contribute to improved employee well-being and productivity while fostering environmentally responsible behavior (Ali et al., 2023; Wahab et al., 2018). Likewise, the adoption of electric material handling equipment and automated systems can reduce emissions and energy consumption while increasing operational efficiency and workplace safety (Ries et al., 2017; Minashkina & Happonen, 2023; Cosma et al., 2025).

The proposed framework expands the scope of sustainable warehousing by incorporating external relational dimensions, namely collaboration with supply chain partners and community engagement. These dimensions are largely absent from existing frameworks, yet they are increasingly recognized as critical components of sustainable supply chain management (Seuring & Müller, 2008; Carter & Easton, 2011). Beyond internal warehouse operations, practices such as reverse logistics initiatives, returnable packaging systems, and collaboration with local suppliers can generate environmental benefits across the supply chain, strengthen stakeholder relationships, and create economic value through improved coordination and resource efficiency. The inclusion of the external dimensions reflects and reinforces the stakeholder-oriented perspective underpinning the framework and acknowledges that sustainability in warehousing extends beyond the physical boundaries of the warehouse.

In particular, the intra-organizational perspective emphasizes the importance of collaboration among supply chain partners, which is essential for improving coordination, reducing resource use, and enhancing the overall sustainability of logistics and warehousing operations. At the same time, the community engagement dimension highlights the role of warehouses in interacting with local stakeholders, for instance, by supporting local businesses through the procurement of materials and services required for warehousing operations. Such initiatives can contribute to broader sustainability objectives while promoting a more responsible and socially embedded approach to logistics and warehousing management.

Overall, the proposed framework adopts an integrative perspective that reflects the systemic nature of sustainability within logistics and supply chain systems, recognizing the interdependence between warehousing operations, supply chain networks, and local communities. Unlike previous frameworks, which often focus on specific operational practices or isolated sustainability dimensions, the proposed model integrates a broader set of operational areas within a unified conceptual structure, explicitly incorporates stakeholder-related dimensions, and establishes a clearer link between sustainability practices and their environmental, social, and economic performance outcomes.

5. CONCLUSION

This study addressed the growing need for integrating sustainability objectives into warehousing operations, recognizing warehouses as strategic nodes within supply chains with relevant environmental, social, and economic impacts. Despite the increasing attention given to sustainable logistics, the literature remains fragmented regarding sustainable warehousing, often focusing on specific practices or isolated dimensions of sustainability. In response, this study proposes a comprehensive framework that consolidates key areas for sustainability improvement in warehouses, grounded in a TBL perspective.

From a theoretical standpoint, this research contributes to the conceptual development of sustainable warehousing by proposing an integrative framework that organizes sustainability initiatives across operational and strategic warehousing areas. The framework builds on existing proposals while expanding their scope by offering a more

holistic structure that captures the interdependence among environmental, social, and economic dimensions of performance. Additionally, by explicitly incorporating stakeholder influence and emphasizing dimensions such as collaboration with supply chain partners and community engagement, the framework reinforces the view that warehousing sustainability extends beyond warehouse boundaries and should be examined as part of a broader supply chain and societal context.

The proposed framework provides a structured tool to support managerial decision-making and self-assessment, enabling organizations to identify priority areas for improvement and to align sustainability initiatives with operational efficiency and performance goals. By mapping key areas (such as infrastructure, energy, water, residues, human resources, equipment, processes, layout, inventory, transport, and external collaboration), the framework can guide warehouse managers in selecting and implementing sustainability practices with measurable impacts. It may also support the definition of sustainability targets, internal auditing, and benchmarking efforts, facilitating a more systematic transition towards sustainable warehousing practices.

Although the present study does not develop a formal set of performance indicators, the framework may also serve as a conceptual basis for the development of sustainability performance measurement systems in warehousing operations. Each operational area identified in the framework can be associated with indicators that allow organizations to monitor environmental, social, and economic outcomes. For example, practices related to energy management may be evaluated through indicators such as energy consumption per square meter of warehouse space or CO_2 emissions associated with warehousing operations. Similarly, waste management practices may be monitored through indicators such as recycling rates or reductions in waste generation, while human resource initiatives may be assessed through indicators related to occupational health and safety, employee well-being, or training hours in sustainability practices. In this way, the framework may support processes of performance evaluation, internal sustainability auditing, benchmarking, and continuous improvement within warehousing operations.

However, this study has limitations that should be acknowledged. First, it is conceptual in nature and based on a narrative literature review, which, while appropriate for

synthesizing emerging research areas, may be subject to selection bias and reduced replicability compared to systematic review methods. Second, the proposed framework has not yet been empirically validated, meaning that the relationships between specific practices and TBL outcomes remain to be tested across different sectors and geographic contexts. Future research should therefore focus on empirically applying and testing the proposed framework in different organizational and sectoral contexts. In particular, future studies could develop operational indicators and measurement approaches associated with the different areas of the framework, enabling a more systematic evaluation of sustainability performance in warehousing operations. Empirical applications could also explore how managers use the framework to support decision-making, internal auditing, benchmarking, and the implementation of sustainability strategies within logistics systems. Attention could be given to applications in Portuguese companies, helping to address an identified gap in the literature and strengthening the external validity of the framework.

REFERENCES

Ali, S. S., Kaur, R., & Khan, S. (2023). Evaluating sustainability initiatives in warehouses for measuring sustainability performance: An emerging economy perspective. *Annals of Operations Research, 324*(1), 461–500. https://doi.org/10.1007/s10479-022-04689-2

Al-Saad, W. K., Al-Talib, M., Nadeem, S., & Garza-Reyes, J. A. (2023). Sustainable warehouse features: A systematic literature review. *Proceedings of the International Conference on Industrial Engineering and Operations Management*.

Amjed, T. W., & Harrison, N. J. (2013). A model for sustainable warehousing: From theory to best practices. *Proceedings of the International DSI and Asia Pacific DSI Conference*, 1892–1919.

Bálint, M., Bányai, T., & Illés, B. (2025). Green innovations in third-party logistics: Managerial reasons, external stakeholder influences and contingencies in the

natural-business-view framework. *Cogent Business & Management.* https://doi.org/10.1080/23311975.2025.2460613

Bataille, C., Waisman, H., Briand, Y., Svensson, J., Vogt-Schilb, A., Jaramillo, M., Delgado, R., Arguello, R., Clarke, L., & Wild, T. (2020). Net-zero deep decarbonization pathways in Latin America: Challenges and opportunities. *Energy Strategy Reviews*, 30, 100510. https://doi.org/10.1016/j.esr.2020.100510

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Burinskiene, A., Lorenc, A., & Lerher, T. (2018). A simulation study for the sustainability and reduction of waste in warehouse logistics. *International Journal of Simulation Modelling, 17(4), 485–497*. https://doi.org/10.2507/IJSIMM17(4)CO3

Carter, C. R., & Easton, P. L. (2011). Sustainable supply chain management: Evolution and future directions. *International Journal of Physical Distribution & Logistics Management, 41*(1), 46–62. https://doi.org/10.1108/09600031111101420

Carter, C. R., & Rogers, D. S. (2008). A framework of sustainable supply chain management: Moving toward new theory. *International Journal of Physical Distribution & Logistics Management, 38*(5), 360–387. https://doi.org/10.1108/09600030810882816

Centobelli, P., Cerchione, R., & Esposito, E. (2017). Developing the WH2 framework for environmental sustainability in logistics service providers: A taxonomy of green initiatives. *Journal of Cleaner Production*, 165, 1063–1077. https://doi.org/10.1016/j.jclepro.2017.07.006

Cosma, A. M. I., et al. (2025). Sustainability impact of automated warehouses in Industry 4.0 logistics systems. *Procedia Computer Science*, 225, 398–407. https://doi.org/10.1016/j.procs.2025.02.044

Doherty, S., & Hoyle, S. (2009). Supply chain decarbonization: Role of transport and logistics in reducing supply chain carbon emissions. World Economic Forum.

Elkington, J. (1997). *Cannibals with forks: The triple bottom line of 21st century business*. Capstone.

Fan, R., Zhang, X., Bizimana, A., Zhou, T., Liu, J. S., & Meng, X. Z. (2022). Achieving China's carbon neutrality: Predicting driving factors of CO2 emission by artificial neural network. *Journal of Cleaner Production*, 362, 132331. https://doi.org/10.1016/j.jclepro.2022.132331

Freeman, R. E. (1984). *Strategic management: A stakeholder approach*. Pitman.

Freis, J., Vohlídka, P., & Günthner, W. A. (2016). Low-carbon warehousing: Examining impacts of building and intralogistics design options on energy demand and CO_2 emissions. *Sustainability, 8*(5), 448. https://doi.org/10.3390/su8050448

He, Z., Chen, P., Liu, H., & Guo, Z. (2017). Performance measurement system and strategies for developing low-carbon logistics: A case study in China. *Journal of Cleaner Production, 156*, 395–405. https://doi.org/10.1016/j.jclepro.2017.04.071

Ifekanandu, C. C., Iloka, C. B., Anukwe, G. I., Eze, J. O., Uwakwe, I. V., & Asagba, S. (2025). Adoption of sustainable fuels and renewable energy in logistics: Examining the role of stakeholder theory in supply chain strategy. *PLoS ONE, 20*(3), e0320507. https://doi.org/10.1371/journal.pone.0320507

Koppiahraj, K., Bathrinath, S., & Venkatesh, V. G. (2021). Optimal sustainability assessment method selection: A practitioner perspective. *Annals of Operations Research*, *324*, 629–662. https://doi.org/10.1007/s10479-021-04104-3

Malinowska, M., Rzeczycki, A., & Sowa, M. (2018). Roadmap to sustainable warehouse. *SHS Web of Conferences, 57*, 01028. https://doi.org/10.1051/shsconf/20185701028

Minashkina, D., & Happonen, A. (2023). A systematic literature mapping of current academic research linking warehouse management systems to the third-party

logistics context. *Acta Logistica, 10*(2), 137–150. https://doi.org/10.22306/al.v10i2.377

Modica, T., Perotti, S., & Melacini, M. (2021). Green warehousing: Exploration of organisational variables fostering the adoption of energy-efficient material handling equipment. *Sustainability, 13*(23), 13237. https://doi.org/10.3390/su132313237

Mulder, S. (2013). *Sustainable warehousing: Empirical research at Unilever on building options and collaboration models in sustainable warehousing* (Master's thesis, University of Twente).

Parmar, B. L., Freeman, R. E., Harrison, J. S., Wicks, A. C., Purnell, L., & de Colle, S. (2010). Stakeholder theory: The state of the art. *Academy of Management Annals, 4*(1), 403–445. https://doi.org/10.1080/19416520.2010.495581

Perotti, S., & Colicchia, C. (2023). Greening warehouses through energy efficiency and environmental impact reduction: A conceptual framework based on a systematic literature review. *International Journal of Logistics Management, 34*(7), 199–234. https://doi.org/10.1108/IJLM-04-2022-0185

Ramaa, A., Subramanya, K. N., & Rangaswamy, T. M. (2012). Impact of warehouse management system in a supply chain. *International Journal of Computer Applications, 54*(14), 14–20. https://doi.org/10.5120/8606-1980

Ren, R., Hu, W., Dong, J., Sun, B., Chen, Y., & Chen, Z. (2019). A systematic literature review of green and sustainable logistics. *Sustainability, 11*(6), 1621. https://doi.org/10.3390/su11061621

Ries, J. M., Grosse, E. H., & Fichtinger, J. (2017). Environmental impact of warehousing: A scenario analysis for the United States. *International Journal of Production Research, 55*(21), 6485–6499. https://doi.org/10.1080/00207543.2017.1334674

Saderova, J., Poplawski, L., Balog, M., Michalkova, S., & Cvoliga, M. (2020). Layout design options for warehouse management. *Polish Journal of Management Studies, 22*(2), 443–456. https://doi.org/10.17512/pjms.2020.22.2.29

Seuring, S., & Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production, 16*(15), 1699–1710. https://doi.org/10.1016/j.jclepro.2008.04.020

Silva, V., Amaral, A., & Fontes, T. (2023). Sustainable urban last-mile logistics: A systematic literature review. *Sustainability, 15*, 4101. https://doi.org/10.3390/su15054101

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research, 104*, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

Torabizadeh, M., Yusof, N. M., Maaram, A., & Shaharoun, A. M. (2020). Identifying sustainable warehouse management system indicators and proposing a new weighting method. *Journal of Cleaner Production, 248*, 119190. https://doi.org/10.1016/j.jclepro.2019.119190

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British Journal of Management, 14*(3), 207–222. https://doi.org/10.1111/1467-8551.00375

Vasileva, A., Lazarevska, A. M., & Jakimovska, K. (2022). Appropriate criteria for a transition from conventional to sustainable warehousing. *Logistics, 6*(1), 19. https://doi.org/10.3390/logistics6010019

Wahab, S. N., Sayuti, N. M., & Talib, M. S. A. (2018). Antecedents of green warehousing: A theoretical framework and future direction. *International Journal of Supply Chain Management, 7*(6), 382–388.

Wei, Y.-M., Chen, K., Kang, J.-N., Chen, W., Wang, X.-Y., & Zhang, X. (2022). Policy and management of carbon peaking and carbon neutrality: A literature review. *Engineering, 14*, 52–63. https://doi.org/10.1016/j.eng.2021.11.007

Xin, L. J., Xien, K. C., & Wahab, S. N. (2019). A study on the factors influencing green warehouse practice. *E3S Web of Conferences, 136*, 01040. https://doi.org/10.1051/e3sconf/201913601040

Yoo, B. C., Kim, J., & Park, S. (2025). Stakeholder pressure and ESG practices in logistics organizations: Implications for sustainable operations. *Sustainability, 17*(2), 1145. https://doi.org/10.3390/su17094243

Żuchowski, W. (2015). Division of environmentally sustainable solutions in warehouse management and example methods of their evaluation. *LogForum, 11*(2), 171–182. https://doi.org/10.17270/J.LOG.2015.2.6

How to cite this article:

Correia, E. (2026). From Practices to Performance: A Triple Bottom Line Framework for Sustainable Warehouse. *Portuguese Journal of Finance, Management and Accounting*, 12 (23), 120 - 142. Disponível em http://u3isjournal.isvouga.pt/index.php/PJFMA. DOI: https://doi.org/10.54663/2183-3826.2026.v12.n23.120-142