

Optimizing Logistics Network Operations in Saudi Arabia Through Lean and Green Supply Chain Management Under Vision 2030

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Abstract- In this review article, the ways in which lean and green supply chain management may work in tandem to optimize the logistics network operation in Saudi Arabia in the era of Vision 2030 will be considered. It is necessary to mention that there is an identified knowledge gap within the existing literature in terms of the approaches applied for the optimization of Saudi logistics. In particular, while logistics modernization in Saudi Arabia is commonly discussed from the perspective of efficiency and logistics hubs or sustainable development and emissions reduction, there is a lack of discussion about the integrated use of lean and green practices. Within the framework of the structured literature review, this paper will analyze peer-reviewed sources and the latest government reports in relation to logistics in Saudi Arabia, its policy, optimization, digitalization, sustainability, and the achievement of Vision 2030 goals, which were published during 2020-2025. As the results of the analysis show, there are certain lean practices such as value stream mapping, inventory optimization, flow coordination, slotting, routing discipline, and root cause problem solving, which, when combined with sustainable practices such as modal shift, fleet optimization, warehouse energy management, re-engineering of logistics packages, reverse logistics, and carbon footprint tracking, can contribute to more effective operation of Saudi logistics networks.

Keywords: *Lean Supply Chain, Green Logistics, Logistics Network Optimization, Saudi Arabia, Vision 2030, Warehousing, Transport Efficiency, Sustainable Supply Chain Management*

I. INTRODUCTION

There is a new paradigm in Saudi Arabia about the nature of logistics in economic transformation. Through Vision 2030 and the National Transport and Logistics Strategy, logistics is no longer seen as a supplementary process. Rather, it is seen as an engine of productivity, an enabler of trade, and a tool for industrial diversification, regional integration, and non-oil development (Vision 2030, 2025; Ministry of

Transport and Logistic Services, 2025). On the one hand, the new logistics strategy has encouraged Saudi companies and institutions to rethink their transport corridors, warehousing hubs, cargo handling platforms, customs operations, and last-mile delivery solutions. On the other hand, Saudi logistics is under increasing pressure to decarbonize, conserve energy, and enhance resilience. All things considered, Saudi logistics is facing a dual responsibility, namely, becoming both lean and green.

Under the lean perspective, the key focus area is the reduction of non-value adding activities in the logistics process. For logistics networks, that includes minimizing any avoidable delay, redundant handling, inefficient slot utilization, unproductive truck trips, inventory overstocks, suboptimal routing, and unstable planning practices. In terms of the green perspective, it involves reducing fuel consumption, lowering emission levels, reducing packaging waste, optimizing facilities' energy use, and promoting greater circularity in materials flow.

Traditionally, these two issues have been tackled separately as cost and service discipline on the one hand, and environmental compliance effort on the other. However, recent literature points out that it is the simultaneous implementation of these two perspectives that yields the most impressive results. Both lean and green depend upon waste visibility, rigorous process control, and system-level optimizations, which cannot be achieved at the local level alone (Alkandi et al., 2024; Gál et al., 2025).

At present, Saudi Arabia constitutes an interesting setting for such synergy. The Kingdom's geographic features contribute to increased distance in inland logistics. Its logistics aspirations, which imply world-class port, airport, rail and inland logistics

infrastructure, are combined with growing importance attached to sustainability, digitalization, and resilience. Finally, the Kingdom is actively improving trade facilitation, logistics connectivity, and the overall logistics environment, all while aligning with its other climate and resources objectives (Invest Saudi, 2025; Vision 2030 Annual Report, 2025). Such conditions call for taking logistics network optimization as an issue of logistics as a system rather than individual facilities. Network effectiveness will depend upon the interaction of nodes, flows, information, and governance among suppliers, carriers, customs, logistics facilities, industry clusters, and end customers.

A substantial body of Saudi-relevant literature confirms that view. Systemic reviews of digital transformation and sustainable supply chains emphasize the significance of visibility and integration for resilience and environmental impact (Alquraish, 2025). Meanwhile, case studies on Saudi Arabian manufacturing and logistics operations point out that a combination of green practices and sustainability-oriented organizational culture and innovation capabilities help to secure positive organizational outcomes. All of that demonstrates that the greening of Saudi logistics and logistics networks is not just a question of implementing separate sustainability projects. Instead, it is also a question of making Saudi logistics systems more sustainable, efficient, and resilient (Herzallah et al., 2025; Alkandi et al., 2025). Moreover, a growing amount of logistics literature on Saudi Arabia highlights that Saudi logistics is undergoing digital, environmentally oriented, and network-focused change (Alasmari & Al-Zahrani, 2025).

However, some gaps still exist in current Saudi logistics research. While a substantial amount of research is devoted to logistics transformation or sustainable supply chain practices in Saudi Arabia, there is still insufficient research on the potential synergies between lean, green, and logistical network operation. In other words, companies understand their need for lower costs, better service, increased resilience, and low emissions. Nevertheless, they lack a systematic approach to how these objectives can be addressed through network optimization and other logistics practices. In order to fill in this gap, the

following paper will present a structured review of the key mechanisms that help to optimize Saudi logistics networks from lean and green perspectives.

The purpose of this paper is to conduct a systematic review of lean and green practices that allow logistics networks in Saudi Arabia under Vision 2030 to achieve effective operation. In particular, this paper aims to answer the following questions. What lean and green practices are most important for Saudi logistics network operation? What operational, technological, and governance factors contribute to the achievement of system-level rather than local effects through lean and green initiatives? How can Saudi organizations implement these lessons in formulating their logistics network optimization strategy?

II. LITERATURE REVIEW AND THEORETICAL LENS

In practice, the distinction between lean and green supply chain management is becoming less pronounced, with the two approaches converging and complementing one another. The former was born out of the field of operations management, centered around the concepts of flow, pull, standardization, visibility, and continuous improvement. The latter was formed through environmental management, circular economy, and sustainability research, emphasizing the reduction of greenhouse gas emissions, resource efficiency, eco-design, reverse logistics, cleaner energy, and compliance. In logistics networks, there is significant overlap, as transportation inefficiency, inventory overbuild, repeated handling, inefficient scheduling, energy use, and packaging waste are at once operational inefficiencies and sources of environmental harm. Recent literature suggests that green performance tends to benefit from the visibility provided by lean operations, while lean performance gains strength from the identification of system waste facilitated by environmental considerations (Gál et al., 2025; Vilaça et al., 2025).

From a Saudi perspective, this convergence is especially pertinent, as logistics modernization goes hand-in-hand with industry diversification and sustainability-focused policies. The Saudi National

Transport and Logistics Strategy positions logistics management as part of a larger integrated industry system meant to improve connectivity and trade while promoting the effectiveness of institutions and businesses (Ministry of Transport and Logistic Services, 2025). At the same time, the strategic goals outlined in Vision 2030 and NIDLP identify logistics management as a key factor in achieving industrial competitiveness and global market access (Vision 2030, 2025; NIDLP, 2025). Thus, in Saudi Arabia's current regulatory and market environment, logistics firms and industries are under growing pressure to optimize logistics networks both operationally and environmentally. The literature coming out of the industrial sector of Saudi Arabia reflects the increasing importance of green supply chain management as a component of competitive advantage and operational resilience (Alkandi et al., 2024; Alkandi et al., 2025).

Network optimization literature also provides a rationale for a dual approach. Traditionally, logistics optimization has considered such factors as total landed costs, facility locations, geographical coverage, vehicle routing, and inventory efficiency. However, modern supply chain management literature recognizes that optimal networks operate using multi-objective logic. No longer is minimizing either transportation or warehousing cost enough; today, firms are required to optimize for cost, delivery times, utilization rate, reliability, resilience, and carbon emissions (Alquraish, 2025; Alasmari & Al-Zahrani, 2025). This is especially relevant to the situation in Saudi Arabia, where long internal distances, export-import flows, cold-chain requirements, and industrial zones create nonlinear interactions between the objectives of inventory concentration and service effectiveness.

In terms of lean logistics, value stream mapping enables the discovery of process waste due to waiting, delays, reworking, underutilized assets, batch processing, and other inefficiencies along the route connecting ports, warehousing facilities, and transportation services. The adoption of standard work, takt alignment, slotting, dock scheduling, and exception management helps maintain consistency in the physical flows generated by logistical networks. Inventory optimization and cross-docking eliminate

unnecessary waiting times, storage congestion, and handling steps. Finally, root cause analysis and visual management ensure that execution stability is achieved – a critical attribute of highly efficient logistics networks where even small process failures can multiply their impact across nodes. In Saudi operations, these techniques become important, as network performance may depend not only on strategic infrastructure but also on planning consistency between carriers, warehousing, customs, and customers.

With green logistics, a second level is added to logistics optimization. Modal switching, route optimization, fuel-efficient transport, energy retrofits, refrigeration optimization, use of renewable energy, packaging design, waste segregation, and reverse logistics can each play a direct role in environmental performance. On the other hand, each of these measures also affects delivery times, cost, and other aspects of performance, as more effective routing leads to better fuel consumption and delivery stability, more efficient packaging minimizes material and cube waste, energy efficiency reduces both emissions and costs, and reverse logistics increases material recovery and return capability. Contemporary research focused on Saudi Arabia and adjacent markets has shown that green improvements tend to be sustainable when integrated into operational processes, technology usage, and informational workflows rather than viewed as standalone corporate social responsibility projects (Herzallah et al., 2025; Abourokbah et al., 2025).

Finally, digitalization serves as a link between lean and green improvements in logistics performance. In recent years, the logistics literature has recognized that digital transformation, control towers, data analytics, IoT sensors, and forecasting help to achieve higher levels of network visibility and optimization (Alquraish, 2025; Alabdali et al., 2025).

From the perspective of lean management, digital technologies enable managers to shorten information latency, detect exceptions, and optimize planning. From the standpoint of green supply chain management, they allow firms to track fuel consumption, emissions, utilization rates, and waste more precisely and explore the results of hypothetical

optimizations. Saudi Arabia's logistics optimization agenda is highly connected to digital transformation through such elements as smart infrastructures, platform solutions, and ecosystem optimization. Therefore, lean–green optimization in the Kingdom will probably require a digital measurement framework that connects operations to sustainability decisions.

The literature also mentions certain conflicts. Lean optimization can potentially increase environmental risks if pursued exclusively through higher utilization rates or outsourcing to environmentally unaware carriers. Sustainability programs can lead to minimal green results if introduced as standalone initiatives instead of integrated into operational design, KPI metrics, and economics. Lastly, digital technology investment can lead to little improvement if new technology is applied to processes that lack stability. Such contradictions call for the development of governance mechanisms that would align the strategic orientation, operational techniques, and measuring frameworks used by firms. This idea has been incorporated into the framework proposed in the next section of this paper.

Thus, the theoretical lenses that frame this research include lean systems thinking, green supply chain management, and dynamic capabilities theory. Lean systems thinking explains the benefits of flow stability, process waste elimination, and pull-based coordination for logistics management. Green supply chain management provides an understanding of how environmental damage can be reduced at every step of supply chain management, from sourcing to warehousing, transportation, packaging, and returns. Dynamic capability logic reveals how companies capable of continuously recognizing operational inefficiencies, discovering opportunities for redesign, and transforming their routines can benefit from both cost and environmental savings under conditions of market and regulatory change (Alquraish, 2025; Herzallah et al., 2025).



Figure 1. Integrated lean–green logistics network optimization framework for Saudi Arabia

III. METHODOLOGY

The methodology selected for this paper involves an appropriately structured literature review, suitable for a review article which intends to synthesize evidence from multiple disciplines as opposed to testing a single empirical hypothesis. Methodologically speaking, the aim was to systematically search, select, and analyze relevant literature that makes connections between Saudi logistics transformation and concepts such as lean, green, digital, and governance as applied to logistics networks.

The review period extended from January 2020 to December 2025 to comply with the user's requirement for citations within this specific timeframe, as well as to focus on the latest developments of the Vision 2030 agenda. Databases included peer-reviewed journal articles, review papers, policy papers, and strategic planning documents. The search terms comprised four clusters including keywords such as “Saudi Arabia” or “Vision 2030”; “logistics” or “transportation” or “warehousing” or “supply chain network”; “lean” or “operational excellence”; and “green” or “sustainable logistics” or “decarbonization” or “green supply chain management.” Other terms such as “digital transformation,” “resilience,” “control tower,” and “circular economy” were used to find enabling conditions and contextualizing studies.

The logic behind the systematic review followed PRISMA-inspired guidelines, adapted for management literature reviews. Step one entailed identification of sources through journals and web searches. In step two, duplicate records and those irrelevant for the purposes of the review were

screened out. Next, titles and abstracts were assessed for their relevance to logistics optimization, lean-green supply chain management, Saudi Arabian industrial or logistics context, and Vision 2030. Finally, full-text assessment involved evaluating the relevance to concepts of logistics optimization, lean-green approach, sector, clarity of results, and transferability to Saudi Arabia's logistics networks.

Studies focusing on sustainability but not logistics operations or vice versa were only included if they provided contextual information.

For data analysis, qualitative synthesis with thematic coding was adopted. Studies deemed appropriate for the purpose were coded along the following seven themes: network design and logistics hubs development; lean logistics and waste reduction; green transportation and warehousing; digital enablers and visibility; resilience and reliability; governance and KPI architecture; and Saudi Arabian context and policies. Those themes were subsequently analyzed with respect to the integrated lean-green approach. The primary role of thematic coding was to identify recurrent mechanisms that connect logistics performance and environmental impact.

To enhance the credibility of this review, preference was given to sources that included at least one of the following elements: Saudi Arabian empirical context; Saudi policy relevance; systematic review or bibliometric methods; analysis of logistics or supply chain operations; and framework that is easily transferable to the industrial logistics of Saudi Arabia. In addition, official documents were used to define the national policy context while scholarly sources were used to develop the analytical framework. The structure of this paper was inspired by the 2026 Discover Sustainability article "Lean-green logistics in global networks" (Alsaadi et al., 2026); however, the content, arguments, tables, and figures are different.

A systematic literature review is appropriate for this research for three reasons. First, Saudi Arabian logistics transformation occurs at various levels – from policy to infrastructure and capability building to environmental management. Second, the lean-

green relation is full of mechanisms and thus requires comparative synthesis across transportations, warehousing, industry, and sustainable management. Third, management practitioners need framework-building evidence for translating disconnected pieces of information into usable models.

Network domain	Lean priority	Green priority	Expected joint impact
Transport lanes	Route discipline, consolidation, time-window adherence	Fuel efficiency, modal shift, emissions visibility	Lower cost per shipment and lower carbon per shipment
Warehousing	Slotting, standard work, reduced dwell time	LED/HVAC optimization, solar integration, equipment efficiency	Higher throughput with lower energy intensity
Inventory positioning	Rationalized stock points, pull replenishment	Reduced obsolescence and waste	Lower working capital and lower disposal losses
Packaging & handling	Damage prevention, cube optimization	Material reduction, reusable packaging	Lower material cost and lower waste
Returns & reverse flows	Standard returns routing, disposition rules	Recovery, reuse, recycling	Higher asset recovery and circularity performance

Table 1. Lean and green interventions for logistics network optimization

IV. RESULTS AND DISCUSSION

From the review, it is clear that logistics network optimization in Saudi Arabia is less concerned with process optimization and more with holistic approaches that take into account network structure, operating practices, sustainability decisions, and governance. Five key findings have emerged from the literature review.

First, the integration of lean and green delivers higher logistics benefits compared to applying the approaches separately. As shown in the studies of green supply chains in Saudi and neighboring industrial regions, the results of sustainability efforts are more sustainable when they are associated with managerial control, process discipline, and learning rather than symbolic sustainability initiatives (Alkandi et al., 2024; Herzallah et al., 2025).

This aspect is relevant to logistics as transportation emissions, energy usage in facilities, empty runs, waiting, and waste disposal all represent examples of unstable and flawed logistics flows. Lean practices identify the location of non-value-adding steps in the network, while green approaches expand the performance criteria to include emissions, energy, packaging, and recycling. In practice, the integration implies a shift in managerial thinking as congested warehouses become not just inefficient operations but also a matter of power inefficiency and unnecessary equipment use; poor routing becomes a freight cost problem but also an emission and driving efficiency issue.

Second, network design emerges as the core lever. Logistics ambitions in the Kingdom rely heavily on how the network nodes such as ports, air terminals, inland logistics zones, industrial areas, and distribution centers are connected and governed. The NTLS emphasizes the importance of integration for this task (Ministry of Transport and Logistic Services, 2025). According to the review literature, the lean-green benefits tend to be higher when logistics companies pursue network design instead of focusing only on local cost reduction. For instance, inventory centralization can help decrease warehouse duplications but increase the amount of long-distance shipping; a decentralized micro-fulfillment approach

could improve service but increase energy inefficiency if facilities are not efficient and slotting is lacking. The optimal solution depends on cost-service-carbon models. Saudi firms thus need decision criteria to choose based on inventory turns, fill rate, order cycle time, truck utilization, energy intensity, and emissions per shipment.

Third, transport optimization continues to be the highest-value opportunity and risk for Saudi logistics firms. The Kingdom's logistics ambitions combine the need for long-distance transportation and hub-based development. Literature reviews indicate that logistics consolidation, route optimization, load balancing, driver discipline, mode selection, and low-carbon transportation fleets are powerful leverage points for lean-green logistics (Alasmari & Al-Zahrani, 2025; Jefimovaitė, 2026). Lean practices include variability reduction through improved dispatching, exception escalation, time-window discipline, and delays analysis; green practices expand the same agenda with the inclusion of fuel conservation, alternative fuels use, potential electrification, and shipment density improvements.

Given the Kingdom's geography, the greatest opportunity for lean-green in Saudi logistics may be the optimization of unnecessary and empty mileage, especially between ports, industrial centers, and urban population hubs.

Fourth, warehouse management is shifting toward strategic sustainability. As indicated by literature reviews and transformation narratives about logistics in Saudi Arabia, warehousing in the Kingdom is moving beyond mere storage of materials to integrated logistics platforms, value-added services, and digital fulfillment (Invest Saudi, 2025; Alquraish, 2025).

Such an evolution creates new opportunities for lean-green logistics. On the lean side, warehousing optimizes productivity by reducing motion, waiting, search, replenishment, and storage activities; green warehousing focuses on energy efficiency, cold chain optimization, lighting, material handling, packaging, and building design. In Saudi logistics, combining these two approaches will allow achieving higher throughput and energy productivity levels; for

instance, visualized warehouses with optimized slotting and minimized wait time will lead to fewer forklift trips, refrigeration leakage, and unnecessary power consumption.

Fifth, digital visibility is the execution framework that allows translating aspirations into performance reality. As shown in the literature reviews on Saudi manufacturing and logistics resilience, digital transformation helps in logistics sustainability when it facilitates visibility and adaptive decision-making rather than just automation of existing processes (Alquraish, 2025; Alabdali et al., 2025).

For logistics networks, such transformation involves setting up control towers, logistics management systems, warehousing systems, customs visibility, and sustainability tracking dashboards and including them in the day-to-day decision-making. Lean logistics requires visibility of process exceptions, throughput, queues, and capacity utilization; green logistics calls for visibility of fuel usage, emissions, energy, waste generation, and sustainability measures. Combining such a digital platform would give Saudi logistics companies the necessary transparency to make trade-offs visible. For example, they would see whether a promised service enhancement was due to network redesign or additional buffer inventories and extra freight capacity.

The review also provides sector-specific implications. Consumer distribution and e-commerce require attention to last-mile density, returns management, and packaging optimization; industrial and business-to-business logistics call for focus on corridor design, plant and warehousing synchronization, and inbound logistics; in the temperature-controlled logistics segment, energy efficiency and dwelling control assume even greater significance due to increased cost and impact on the environment. However, regardless of the logistics sector, the same conclusion applies – logistics network optimization necessitates integration.

From the thematic analysis, three principles can be derived. First, the principle of network-level analysis of waste. Although many companies today analyze waste at the process level, Saudi logistics

increasingly requires network-level waste identification. In particular, it involves examining inter-node wait times, handoff losses at customs clearance to the warehouse, repetitive handling among multiple handlers, and misalignment between transportation and labor schedules at the warehouse.

Second, the principle of balanced metrics. Managing only freight costs will inevitably increase carbon footprint; managing only emissions will harm service or working capital. Balanced metrics involve combining multiple dimensions of logistics, including costs, services, resilience, and sustainability into the dashboard. Finally, the principle of regular reviews by stakeholders with different roles in logistics. Lean-green performance is maximized when executives, operational managers, and analysts regularly discuss the same metrics in the same rhythm.

Building on the above findings, a possible logistics optimization framework for Saudi companies could involve five layers. Strategic intent would translate the Kingdom's vision and company goals into logistical priorities such as hub connectivity, service delivery, decarbonization, and resilience. The next layer, network design, deals with defining roles and interactions of logistics nodes, routes, inventory management, and partnerships. The third layer, process excellence, applies lean management principles to warehouse and transport management, cargo handling, and returns. The fourth layer, green enablement, would integrate energy, emission reduction, packaging optimization, transportation modes, and circular economy into processes defined at the previous layer. Finally, governance and analytics provide the measurement framework for performance optimization.

Saudi firms thus need to go beyond simple reporting and instead conduct thorough flow analysis followed by network redesign and digitization of the new network logic.

For Saudi policymakers and other ecosystem participants, several recommendations emerge from the review. While continued infrastructure investments remain critical, lean-green performance is not ensured by investments alone. The role of

policies should be to facilitate data standardization, logistics capabilities of small- and medium-sized enterprises, incentive programs for green logistics technologies, and collaboration platforms among shippers, logistics service providers, ports, and industrial areas. Monsha'at's initiatives in this area can be relevant in light of the expected role of SMEs in the future supply chain performance.

Overall, the literature suggests that Saudi Arabia is ready to develop a unique logistics optimization model, which includes hub strategy, digital visibility, lean logistics, and green performance. While integration of lean and green is hardly a controversial topic, the true challenge lies in implementing network optimization and changing operational management practices and performance metrics rapidly.

One of the final themes emerging from the literature concerns measuring logistics sustainability and performance. To optimize something, a company needs to measure the relevant variables. The review indicates the need for tiered logistics KPIs at Saudi companies. At the strategic level, companies should monitor total logistics costs, reliability of order delivery, working capital intensity, transport carbon emissions, energy intensity in warehouse management, and recovery rates/flows. At the tactical level, t...



Figure 2. Phased roadmap for implementing lean–green logistics optimization in Saudi organizations

Implementation barrier	Saudi-relevant manifestation	Lean-green response	Primary KPI
Fragmented data	Carrier, warehouse, and customs data are not synchronized	Control-tower visibility and common review cadence	Exception closure time
Local optimization	Sites optimize their own budgets rather than network outcomes	Balanced cost-service-carbon governance	Total logistics cost and OTIF
Transport inefficiency	Empty miles, partial loads, route deviations	Load consolidation and dispatch discipline	Vehicle fill rate / empty km
Facility energy intensity	Cooling and handling equipment consume excess power	Energy monitoring plus process redesign	kWh per order / per pallet
Capability gaps	SMEs lack analytics and sustainability routines	Targeted training and phased deployment	Improvement actions closed

Table 2. Barriers, responses, and KPI logic for Saudi lean–green logistics execution.

V. CONCLUSION

This literature review aimed to provide an explanation of how lean and green supply chain management may be used to enhance the efficiency of logistics networks in Saudi Arabia under Vision

2030. One critical conclusion made was that lean and green may prove extremely effective if considered as complementary operating paradigms rather than independent programs. Lean improves flow, reliability, and visibility of waste; green expands the scope of performance to incorporate energy use, emissions, resource efficiency, and circular economy. Considering that logistics networks in Saudi Arabia witness simultaneous advances in national competitiveness, logistics infrastructure modernization, and sustainability goals, the intersection of lean and green logics is strategic.

In this regard, the literature review indicates that the most significant drivers of performance are network design, transportation discipline, warehousing efficiency, visibility of exceptions, and cadence of governance. Companies pursuing green logistics or reporting on sustainability will likely not experience any significant transformation. However, firms reimagining their network structure and processes, controlling deviations, automating exceptional cases, and managing trade-offs between costs, services, and carbon will most likely deliver meaningful results. These findings constitute the primary message for managers and policymakers – logistics optimization is a systems-level capability.

Hence, this paper delivers the following contributions – an integrated Saudi-relevant framework and a phased roadmap that could facilitate implementation in ports, industrial logistics, distribution networks, and service providers. The proposed framework aligns with Vision 2030 since it establishes the connection between logistics hub creation, operational efficiency, resilience, and environmental responsibility. Practically, Saudi firms need to shift from piecemeal logistics activities towards network-based transformations based on a portfolio of investments and common metrics reviewed by executive leaders.

VI. LIMITATIONS AND FUTURE RESEARCH

It is worth acknowledging that there are certain limitations associated with this literature review. First, it is structured and cannot be classified as a meta-analysis, which means it synthesizes mechanisms and implications for managers but does

not estimate pooled effect sizes. Second, although Saudi Arabia is the key context, some evidence is drawn from studies conducted within other sectors and regions, since studies focused on lean-green logistics networks in Saudi Arabia are still emerging. Third, policy sources are crucial for contextual information but not enough to substitute organizational data.

For future research, it is recommended to validate the proposed framework through Saudi cases, multi-firm surveys, corridor-level logistics datasets, and longitudinal decarbonization indicators. Possible research areas might include carbon-aware logistics network design, green warehouses in hot climates, low-emission corridor management, logistics capabilities of SMEs, and digital control towers for sustainability and reliability.

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