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SYSTEMATIC LITERATURE REVIEW ON DEVELOPING A DECISION SUPPORT FRAMEWORK TO MINIMIZE LOSS MILEAGE AND ITS IMPACT IN SRI LANKA'S FMCG TRANSPORTATION SECTOR: A CASE-BASED DELPHI-ISM APPROACH

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ABSTRACT

The Fast-Moving Consumer Goods (FMCG) sector in Sri Lanka depends on high frequency, time sensitive deliveries, where "loss mileage" (unproductive/empty travel) erodes cost efficiency, asset utilization, and service reliability. This systematic literature review (SLR) consolidates fragmented evidence on drivers of loss mileage and their cost implications to ground a context specific decision support solution. Searches were conducted across Google Scholar (primary), IEEE Xplore, and ScienceDirect using a structured Boolean string targeting loss mileage/empty mile, FMCG logistics, Transportation Management Systems (TMS), decision support, and Delphi/ISM methods. Following PRISMA procedures and predefined inclusion-exclusion and quality criteria, 48 studies were retained (16 from the direct query; 32 added via snowballing and targeted subdomain searches). The synthesis yields a validated set of 15 high leverage factors prioritized by frequency in literature, cost impact, consolidation of overlaps, and impact intensity including transportation utilization, load efficiency, route and infrastructure design, vehicle performance and reliability, idle fuel consumption, driver scheduling, cold chain logistics, and enforcement against overloading. Mapped cost areas span fuel, maintenance, labor/time, and service levels. analytics: exposes four persistent gaps: (i) absence of an integrated, context-aware framework to minimize loss mileage; (ii) underutilization of TMS data for predictive/optimization

analytics; (iii) limited combined application of Delphi with Interpretive Structural Modelling (ISM) anchored in operational datasets; and (iv) scant Sri Lanka specific empirical work. Addressing these gaps, the paper motivates a case-based Delphi-ISM decision support framework that fuses expert consensus with TMS evidence to structure causal linkages among factors and guide managerial interventions for measurable cost reduction.

Keywords: Decision Support, Delphi Method, FMCG Logistics, Interpretive Structural Modelling (ISM), Loss Mileage

1. Introduction

1.1. Background

The Fast-Moving Consumer Goods (FMCG) sector in Sri Lanka is a key driver of economic activity, with high product turnover, short lead times, and frequent, reliable delivery requirements. Transportation efficiency underpins supply chain performance, shelf availability, and customer expectations (ESCAP, 2022). A major operational challenge is loss mileage, defined as distance travelled by fleet vehicles without a productive load (Ali et al., 2021), which increases fuel consumption, vehicle maintenance costs, labor inefficiencies, and reduces asset utilization (Gunawardana et al., 2022; Perera et al., 2021). Globally, loss mileage is linked to poor route planning, low load consolidation, vehicle-location assignment mismatches, and missed backhaul opportunities (Mathiyazhagan et al., 2013; Palit et al., 2022). In Sri Lanka's FMCG context, these issues are amplified by infrastructural constraints, uneven demand distribution, and the lack of advanced, context-specific optimization tools (Kodikara et al., 2021).

Despite widespread adoption of Transportation Management Systems (TMS), most organizations underutilize their analytical capabilities: more than 60% use TMS mainly for monitoring rather than predictive or optimization-driven decision-making (Ranaweera et al., 2022). This limits the detection of systemic inefficiencies such as high deadhead ratios, ineffective depot positioning, and suboptimal scheduling (Fernando et al., 2021). Decision Support Systems (DSS) have improved logistics operations (Wickramasinghe et al., 2020), but many existing models, developed for mature economies, do not reflect the operational

constraints and behavioral patterns of developing countries (De Silva et al., 2022; Kodikara et al., 2021). Integrating expert-driven approaches such as the Delphi method (Jayasinghe & Wijayanayake, 2020) with systemic modelling techniques like Interpretive Structural Modelling (ISM) (Ranathunga et al., 2020; Wijesundara et al., 2021) therefore presents an untapped opportunity to address the multifactorial nature of loss mileage. Conducting a Systematic Literature Review (SLR) will consolidate fragmented research, provide an evidence-based understanding of loss mileage drivers, and lay the foundation for a tailored decision support framework.

1.2. Problem Statement

Loss mileage remains a significant operational inefficiency in Sri Lanka's FMCG transportation sector, inflating costs and reducing resource utilization. Although TMS platforms generate vast volumes of operational data, they are seldom analyzed strategically to identify and mitigate root causes of unproductive mileage. Current decision-making practices are predominantly reactive, and no structured, data-driven framework exists that integrates local operational realities, expert judgment, and systemic modeling. The absence of such a framework hampers the ability of logistics managers to isolate and address interrelated factors affecting loss mileage and its associated cost implications.

1.3. Literature Review

Existing literature highlights that loss mileage is influenced by diverse and interconnected factors, including transportation utilization rate, load efficiency, vehicle performance and reliability, route infrastructure design, cold chain logistics, and overloading enforcement. These factors, drawn from global and regional studies, impact multiple cost areas such as fuel expenditure, maintenance, delivery reliability, and service levels (Ali et al., 2021; ESCAP, 2022; Mathiyazhagan et al., 2013).

Research also emphasizes that analytical tools like DSS can significantly improve decision-making in transportation (Wickramasinghe et al., 2020). However, studies in developing economies reveal that imported DSS frameworks often fail to accommodate local constraints,

necessitating context-specific models (De Silva et al., 2022; Kodikara et al., 2021). Methodologies such as Delphi and ISM have been successfully applied in transportation and logistics research to prioritize and structure complex factor sets (Jayasinghe & Wijayanayake, 2020; Ranathunga et al., 2020; Wijesundara et al., 2021), yet their combined application with real-world TMS data in Sri Lanka's FMCG sector remains unexplored.

1.4. Aim and Scope of the Literature Review

The aim of this SLR is to systematically identify, analyze, and synthesize research on loss mileage in FMCG transportation, with particular emphasis on Sri Lanka. It (i) identifies key factors contributing to loss mileage in global and local studies, (ii) examines methodological approaches especially Delphi and ISM used in related domains, (iii) maps interrelationships among these factors and their cost implications, and (iv) highlights research gaps to guide the design of a context-specific decision support framework. Beyond managerial use, the resulting framework is expected to support Sri Lankan regulators in addressing sector-wide issues such as overloading enforcement, realistic delivery windows, and corridor/infrastructure planning through evidence-based prioritization of intervention levers. The scope is limited to peer-reviewed journal articles, conference papers, institutional reports, and relevant industry publications from roughly the last two decades that focus on FMCG transportation, loss mileage, decision support systems, and logistics optimization in both global and Sri Lankan settings.

1.5. Theoretical Rationale for Combining Delphi-ISM:

Delphi uses iterative, anonymous rounds to refine expert judgement and build consensus on a context-specific set of factors and their directional influences, producing a validated Structural Self-Interaction Matrix (SSIM) that specifies which factor influences which and how (V/A/X/O relations). ISM then transforms this consensual SSIM into a transparent causal structure using reachability and transitivity logic, generating the reachability matrix, level partitioning, MICMAC classification, and the digraph/final model. Together, Delphi-ISM reduces modeler subjectivity, provides a traceable rationale for each link, and yields a decision-ready hierarchy of driver and dependent factors; in this study,

Delphi outputs are further triangulated with real TMS signals, so the ISM structure remains grounded in Sri Lanka's FMCG reality and aligned with the review's aim and scope.

2. Methodology

2.1. Database Selection

To build a comprehensive and balanced literature base, three databases were used for their coverage of peer-reviewed research, conference proceedings, and authoritative reports. Google Scholar served as the primary source due to its broad multidisciplinary reach and ability to capture both global and Sri Lanka specific work on FMCG transportation, decision support frameworks, and expert driven modelling. IEEE Xplore was used to identify studies on transportation technology, optimization, and decision support systems with advanced computational components. ScienceDirect complemented these by providing strong coverage in transportation engineering, operations management, and applied decision support systems.

Search Strings/Keywords:

Main Query (used for Google Scholar and IEEE Xplore):
("loss mileage" OR "empty miles" OR "unproductive travel" OR "backhaul inefficienc*" OR "empty kilometer*" OR "empty kilometre*") AND ("transport*" OR logistics OR fleet) AND ("fast moving consumer goods" OR FMCG OR retail distribution) AND ("transportation management system" OR TMS) AND ("decision support" OR DSS OR "decision support framework" OR "decision support system") AND (Delphi OR "Delphi method" OR "expert-driven" OR "expert opinion" OR ISM OR "Interpretive Structural Modeling") AND ("Sri Lanka" OR "developing countr*" OR "emerging market*")

Custom Query for ScienceDirect:
Because ScienceDirect limits very long Boolean strings, the query was shortened to retain only the core concepts while remaining compatible with its search engine and preserving the specificity of the research scope:

TITLE-ABSTR-KEY ("empty mile*" OR backhaul* OR "unproductive travel") AND transport* AND "fast moving consumer goods" AND TMS AND "decision support" AND Delphi AND "Sri Lanka")

Search Outcomes and Scope Expansion:
The database search initially yielded 16 relevant records from Google Scholar and none from IEEE Xplore or ScienceDirect, even with the custom query. Due to this limited retrieval, the scope was expanded using snowballing (reviewing references and citations of the initial papers) and targeted searches in related subdomains such as transportation inefficiency in developing countries, logistics DSS, and Delphi/ISM applications in supply chains, resulting in a final pool of 48 papers for detailed review. Of these, 16 directly matched the original query, while the remaining studies, though not captured by the exact string, were included because they addressed key themes operational factors causing loss mileage, decision support system design, and Delphi-ISM integration and met the inclusion criteria at full-text screening.

2.2. Inclusion and Exclusion Criteria

The review included peer-reviewed journal articles, conference papers, theses, and authoritative institutional/industry reports that (i) addressed transportation inefficiencies, decision support systems/frameworks, and/or expert-driven modelling in FMCG or equivalent distribution sectors; (ii) were conducted in Sri Lanka, other developing or emerging markets, or presented globally transferable methodologies; and (iii) were published in English. Studies were excluded if they were unrelated to transportation/logistics, outside FMCG or retail distribution contexts, lacked full-text access, or were duplicate records across databases.

2.3. Screening and Selection Process (PRISMA Flow Diagram)

The screening process followed PRISMA guidelines. Records identified from database searches (Google Scholar, IEEE, ScienceDirect) were deduplicated, screened by title and abstract against the inclusion criteria, and then subjected to full-text review for thematic relevance. Additional studies were identified through snowballing and targeted subdomain searches, as summarized in the PRISMA flow diagram (Figure 1).

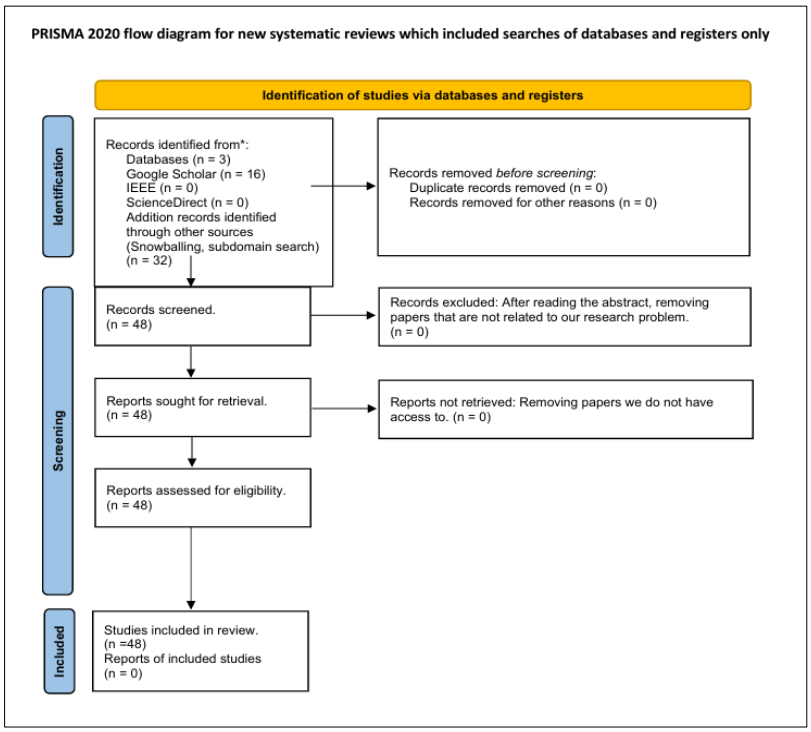

Figure 1: PRISMA Flow Diagram

2.4. Quality Assessment Criteria

Each study was appraised against five criteria: (i) relevance to FMCG transportation and/or loss mileage reduction; (ii) clarity of methodological design (e.g., explicit use of Delphi, ISM); (iii) transparency of data sources and analysis; (iv) applicability to the Sri Lankan or comparable developing-market context; and (v) scholarly credibility (peer-reviewed status, citation record). A study was retained if it satisfied at least three of these five criteria (Mathiyazhagan et al., 2013; Palit et al., 2022).

2.5. Data Extraction Approach

Data were captured using a structured extraction template covering author(s) and year; study location and scope; objectives and methodology; key findings on loss mileage and transport efficiency; identified factors/KPIs and their measurements; and impacted cost areas. The preliminary Factors sheet was used to align extracted evidence with the thematic factor map and the operational indicators required for the proposed decision support framework.

3. Results and Discussion

3.1. Descriptive Analysis

The literature search and selection followed the PRISMA framework (Figure 1). Initial database queries yielded 16 records from Google Scholar and none from IEEE Xplore or ScienceDirect (despite the custom query). To address this limitation, the scope was expanded through snowballing of references and citations and targeted searches in related subdomains (e.g., transportation inefficiency in developing countries, logistics decision support systems, Delphi/ISM applications in supply chains), adding 32 studies for a final set of 48 papers. Of these, 16 matched the full Boolean query, while 32 were included based on thematic relevance and methodological fit with the review objectives; all met the minimum quality criteria outlined in Section II.D. Most publications appeared between 2015 and 2025, reflecting growing interest in transportation efficiency in FMCG and related sectors across both developed and developing contexts, although explicitly Sri Lankan work remains limited. Methodologically, the set is dominated by quantitative modelling, case studies, and multi-criteria decision-making approaches, with Delphi and ISM used in a smaller but notable subset of studies.

3.2. Thematic Synthesis of Findings

From the reviewed literature, a broad set of factors influencing loss mileage in FMCG transportation was identified. Applying four selection criteria (i) frequency of mention across independent studies, (ii) demonstrated cost impact on fuel, asset utilization, labor/time, and

profitability, (iii) consolidation of overlapping constructs (e.g., fleet versus asset utilization) to avoid redundancy, and (iv) impact intensity based on empirical leverage for loss mileage reduction; resulted in a final list of 15 key factors (Table 1) that focus the framework on the most influential intervention areas.

Table 1: Final Factor List

No.	Factor	Brief Description	Example References
1	Transportation utilization rate	Ratio of productive to total travel distance, indicating fleet efficiency	(Ali et al., 2021; Gunawardana et al., 2022)
2	Load status & efficiency	Degree of load capacity utilization, avoiding partial or empty hauls	(ESCAP, 2022; Mathiyazhagan et al., 2013)
3	Transportation efficiency	Overall operational performance in terms of cost, time, and service quality	(Palit et al., 2022)
4	Asset utilization	Optimization of vehicle and equipment usage over their lifecycle	(Kodikara et al., 2021)
5	On-time delivery performance	Adherence to planned delivery schedules	(Fernando et al., 2021)
6	Lead time reliability	Consistency in transit time performance	(Perera et al., 2021)
7	Idle time fuel consumption	Fuel wasted during non-moving periods (e.g., traffic, loading delays)	(ESCAP, 2022)
8	Drive schedule impact	Effect of driver scheduling on route efficiency and compliance	(Jayasinghe & Wijayanayake, 2020)
9	Vehicle performance & reliability (VPR)	Mechanical reliability and performance characteristics influencing uptime	(Ranathunga et al., 2020)
10	Route infrastructure design	Quality and suitability of transport infrastructure for FMCG distribution	(Wijesundara et al., 2021)
11	Internal powertrain efficiency	Energy efficiency of vehicle propulsion systems	(De Silva et al., 2022)

12	Road load attrition (RLA)	Wear and tear on vehicles due to route conditions and load characteristics	(ESCAP, 2022)
13	Fleet modernization	Adoption of newer, more efficient vehicles and technology	(Wickramasinghe et al., 2020)
14	Cold chain logistics	Temperature-controlled transportation to prevent spoilage	(Kodikara et al., 2021)
15	Overloading enforcement	Regulatory compliance and prevention of overloading practices	(Mathiyazhagan et al., 2013)

3.3. Comparative Analysis across Studies

The comparative synthesis shows that while certain factors such as load efficiency, route design, and vehicle reliability are universally recognized across contexts, others such as cold chain logistics and internal powertrain efficiency appear predominantly in sector specific or technology focused studies.

In developed market studies, technological integration (e.g., real-time TMS analytics) was found to significantly mitigate loss mileage by enabling dynamic route optimization and load consolidation (Fernando et al., 2021; Wickramasinghe et al., 2020). However, in developing country contexts, structural issues such as inadequate infrastructure, inconsistent regulatory enforcement, and fragmented supply chains limit the extent to which such solutions can be applied without adaptation (ESCAP, 2022; Kodikara et al., 2021).

The analysis confirms that a hybrid approach combining expert input (Delphi) to contextualize factors and structural modeling (ISM) to map their interrelationships can address both the operational and contextual challenges faced by Sri Lanka's FMCG transportation sector.

4. Research Gap

4.1. Identify Gaps based on the Findings

The SLR highlights five main gaps in the literature on loss mileage reduction in FMCG transportation, especially for Sri Lanka and similar developing contexts.

1. **Lack of integrated frameworks** - Studies often treat factors such as load efficiency, route design, and vehicle reliability in isolation and rarely propose integrated decision support frameworks that combine expert knowledge with data driven analytics or are tailored to FMCG operations in developing economies.
2. **Underutilization of TMS data** - Although TMS platforms are widely implemented, they are mainly used for monitoring; no identified study fully exploits real-time or historical TMS data to quantify how specific factors contribute to loss mileage in FMCG transport.
3. **Limited use of combined Delphi-ISM** - Delphi and ISM appear separately in some logistics studies, but there is no evidence of their combined application with operational datasets in loss mileage research, particularly in Sri Lanka.
4. **Insufficient coverage of emerging operational factors** - Cold chain logistics, internal powertrain efficiency, and overloading enforcement are under-researched in FMCG contexts, leaving their interaction with traditional loss mileage drivers poorly understood.
5. **Contextual disconnect** - Many optimization models are derived from developed-market cases whose infrastructural, regulatory, and technological conditions differ markedly from Sri Lanka, limiting direct applicability without substantial adaptation.

4.2. Link Them to the Need for Research

These gaps highlight the absence of a holistic, context specific approach to minimizing loss mileage in Sri Lanka's FMCG transportation sector. The proposed research responds by integrating expert input and real operational data to identify and prioritize high-impact factors; applying Delphi and ISM together to capture both expert consensus and structural relationships; and leveraging TMS data to empirically ground factor linkages and cost impacts. By focusing explicitly on the Sri Lankan FMCG context, the study aims to produce recommendations that are directly actionable within local infrastructural and regulatory constraints,

making a theoretical contribution by extending the methodological toolkit for loss mileage analysis and a practical contribution by delivering a decision support framework for improving operational efficiency and cost effectiveness.

5. Conclusion

5.1. Summarize Key Findings and Their Implications

This systematic literature review examined 48 studies addressing factors that contribute to loss mileage in FMCG transportation, with a focus on integrating decision support frameworks, expert-driven methodologies, and context-specific adaptations for developing markets.

The review identified 15 critical factors including transportation utilization rate, load efficiency, route infrastructure design, vehicle reliability, and cold chain logistics that significantly influence unproductive mileage and associated cost impacts. These factors were selected through a structured process based on frequency in literature, cost impact, merging of overlapping elements, and impact intensity.

The analysis also revealed that while individual factors are well documented, there is a lack of integrated frameworks that systematically link these factors and provide actionable guidance for decision makers in FMCG logistics. Moreover, the potential of TMS data remains largely untapped, with most existing studies focusing on monitoring rather than predictive and optimization capabilities.

From a methodological perspective, the combined application of Delphi (to capture expert consensus) and ISM (to map interrelationships) is notably absent in the literature, particularly in the Sri Lankan FMCG context. This gap represents both a theoretical and practical opportunity to enhance logistics decision making.

5.2. Set the Stage for Research

Building on these insights, the proposed research will develop a decision support framework that leverages TMS operational data and expert

input to identify, prioritize, and model loss mileage factors. Delphi will be used to reach consensus on the most critical factors and their characteristics, while ISM will structure them into a logically sequenced model that clarifies cause-effect relationships. The framework will be validated with industry practitioners to ensure practical usability and relevance. By addressing the identified gaps, the study aims to deliver a context-specific, empirically grounded, expert-informed framework that enhances operational efficiency, cost effectiveness, and sustainability in Sri Lanka's FMCG transportation sector. The findings of this SLR therefore provide a solid foundation for the next phase of the study, anchoring the proposed framework in both global best practices and local operational realities.

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