

Business Intelligence for Sustainable Logistics Performance in SMEs: A Systematic Literature Review and Research Agenda

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Abstract

Background: Global logistics generates 16–25% of greenhouse gas emissions, yet small and medium-sized enterprises (SMEs) in developing economies lack the digital infrastructure to measure and improve their sustainability performance. Business intelligence (BI) systems can support data-driven sustainability decisions, but their application in SME logistics remains poorly understood, and no prior review has examined this intersection with a developing-economy focus. **Methods:** We conducted a systematic literature review following PRISMA 2020 guidelines, searching Scopus, Web of Science, and IEEE Xplore for peer-reviewed articles published between 2015 and April 2026. Two reviewers independently screened 412 records; 67 studies met inclusion criteria. **Results:** Five thematic clusters emerged: BI tools for logistics, sustainability KPI frameworks (triple bottom line [TBL], environmental–social–governance [ESG], Sustainable Development Goals [SDGs]), ERP integration, SME-specific barriers, and geographic gaps. Of the studies, 92% originate from developed economies; Africa and MENA remain almost entirely absent. No study combines open-source ERP with a validated TBL KPI framework for logistics SMEs. **Conclusions:** We propose a six-priority research agenda targeting empirical validation in developing economies and open-source BI solutions for SME logistics sustainability.

Keywords: business intelligence; sustainable logistics; systematic literature review; SME; triple bottom line; ERP; developing economies

1. Introduction

Global logistics has entered a period of rapid transformation, driven by several converging forces. E-commerce growth, tighter environmental regulations concerning emissions, and the spread of Industry 4.0 technologies are reshaping, at the global level, how goods move across supply chains [1–5]. The sector was valued at roughly US\$8.96 trillion in 2023 and could reach US\$15.79 trillion by 2028, according to the estimates of Kayikci [6]; yet transport and warehousing alone generate an estimated 16–25% of global greenhouse gas emissions [7–9]. The 2030 Agenda for Sustainable Development has shifted sustainability from a reporting afterthought into a strategic priority rather than a mere reporting obligation [10], and logistics firms now face, in consequence, real pressure to quantify their triple bottom line (TBL) performance across economic, social, and environmental dimensions [11–13].



Academic Editor: Rameshwar Dubey

Received: 24 May 2026

Revised: 26 June 2026

Accepted: 29 June 2026

Published: 10 July 2026

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Business intelligence (BI) systems, which consist of data warehousing, ETL pipelines, dashboards, and decision-support tools, offer one way to address this pressure [14–16]. By consolidating data, by means of ETL processes, from different operational sources to create a single performance view, BI permits logistics managers to track key performance indicators (KPIs) in real time, spot inefficiencies concerning resource use, and connect daily decisions, by means of KPI monitoring, to longer-term sustainability targets [17–19]. As the work of Neves [14] and the studies by Giacobbe et al. [20] and Gupta et al. [21], have each shown that BI-enabled logistics firms achieve measurable reductions in carbon footprint and improvements in ESG reporting quality.

For small- and medium-sized enterprises (SMEs), though, the situation differs considerably. SMEs make up about 90% of all businesses worldwide, as World Bank data confirm [22], and perform a large share of logistics activity, especially in developing economies. On the other hand, they rarely have the budget, IT staff, or data skills to run commercial BI platforms like SAP Analytics Cloud or Power BI [23–25]. The upshot is a measurement gap: large firms can track and optimise their logistics sustainability, while SMEs remain unable to show TBL compliance to customers, regulators, or investors [26–28].

Open-source ERP platforms offer, in practice, a partial solution. Odoo Community Edition, for instance, provides modules for inventory, fleet, HR, and accounting at zero licencing cost, thanks to community development [29]. Paired, by means of API connectors, with open-source analytics tools, these platforms could help SMEs build sustainability dashboards without incurring the expense of enterprise-grade software [30–32]. Yet the academic literature on open-source ERP + BI for sustainable logistics in SMEs remains limited and scattered [15,21,33].

No systematic literature review (SLR) has examined specifically how BI is applied to sustainable logistics performance, more particularly with an explicit SME and developing-economy focus. Existing reviews either cover BI in supply chain management broadly, without an SME lens [1,15,16,34–36] or look at sustainable logistics without treating BI as a distinct technology layer [2,3,37,38]. This limits, in practice, both theory and practice for the majority of the world's logistics operators. We address this gap by means of a PRISMA 2020-compliant SLR built around four research questions:

RQ1: What BI tools and technologies have been applied to measure and improve sustainable logistics performance?

RQ2: What sustainability KPI frameworks (TBL, ESG, SDG) are used in BI-enabled logistics?

RQ3: What are the specific challenges and enablers of BI adoption for sustainable logistics in SMEs?

RQ4: What gaps exist in current research, particularly for developing economies such as Morocco and Sub-Saharan Africa?

We make three contributions. First, this is one of the first SLRs that sits at the intersection of BI, sustainable logistics performance, and SME management, drawing on the Technology–Organisation–Environment (TOE) framework [39] and the Resource-Based View (RBV) [40] to interpret adoption patterns. Second, it synthesises 67 peer-reviewed studies into a thematic framework that maps, at the global level, the dominant tools, KPI architectures, and adoption barriers. Third, it puts forward a six-priority research agenda aimed at developing-economy contexts and open-source ERP-based BI solutions.

2. Literature Review

2.1. Business Intelligence in Logistics

BI covers, in broad terms, a range of technologies and processes for collecting, integrating, analysing, and presenting business data [15]. In the logistics field, typical application concerns, more particularly, demand forecasting, fleet monitoring, warehouse throughput

tracking, and sustainability reporting [3,14,17]. Thanks to cheaper IoT sensors, cloud computing, and more accessible analytics platforms, the shift from batch reporting to, thanks to cloud computing, real-time interactive dashboards has accelerated in a considerable manner over the past five years [4,41,42].

Power BI, Tableau, and QlikView dominate the commercial BI market, each supporting, by means of connectors, ETL pipelines from ERP data sources to visual dashboards [14,19]. Marques and Santos [15] and Seddigh et al. [34] both found that combining BI with operations research (OR) methods produces, in practice, better sustainability outcomes than using either approach on its own, contrary to what single-tool advocates claim [18,43]. The barriers for SMEs remain, on the one hand, high; on the other hand, implementation costs and low data literacy, more particularly, appear as top constraints in 78% of studies on SME BI adoption [23–25]. Indeed, for micro and small enterprises (MSMEs) more particularly, the difficulty extends beyond technology, green lean six sigma deployment, for instance, requires organisational readiness that many MSMEs simply lack [39]. Recent work on circular economy integration with Industry 4.0 machine learning techniques is in line with the view that MSMEs need tailored, low-complexity solutions rather than scaled-down enterprise tools [44–46].

2.2. Sustainability Performance Measurement: TBL, ESG, and SDGs

The triple bottom line concept introduced by Elkington [47] remains, by and large, the dominant theoretical lens for sustainability measurement in logistics. TBL splits performance into economic (cost efficiency, resource productivity), social (labour welfare, occupational health, community impact), and environmental (carbon emissions, energy use, waste) dimensions [13,48,49]. More recent studies have also highlighted the integration of sustainability indicators into Balanced Scorecard frameworks for logistics performance measurement [50–52]. Typical logistics KPIs include transport cost per tonne kilometre, CO₂ per delivery, overtime ratios, and packaging waste volumes [26,51,53].

Since 2022, ESG reporting has, thanks to regulatory pressure, gained traction quickly. European mandates, like the Corporate Sustainability Reporting Directive (CSRD) and the European Sustainability Reporting Standards (ESRS), have pushed firms to go beyond TBL by adding a governance layer that covers transparency, board accountability, and anti-corruption [11,12,54–56]. SDG alignment, especially SDG 9, SDG 12, and SDG 13, has become a parallel reporting expectation, more particularly because institutional investors, as Chen et al. [7] document, now ask logistics firms to show concrete SDG contributions [7,10,16,28].

2.3. ERP Systems and Open-Source Solutions for SMEs

ERP systems are the operational backbone of logistics, tying, by means of a single database, procurement, inventory, fleet, warehousing, and finance into a single entity [31,33,57]. SAP S/4HANA and Oracle dominate among large firms, but SMEs turn increasingly to cloud-based or open-source alternatives on account of cost, more particularly licencing fees [23,32,58,59]. Odoo, a Belgian open-source platform with over 12 million users, is noteworthy in this respect, thanks to its modular design: it offers modular deployment, Python Version 3.11-based customisation, and straightforward connections, by means of APIs, to third-party BI tools [29,30]. ERP data, order records, fleet logs, HR entries, and financial accounts supplies the raw material from which BI dashboards compute TBL KPIs [4,21,60,61]. We should add, on the other hand, that open source does not mean cost-free: implementation, customisation, staff training, and ongoing maintenance still represent significant outlays for very small enterprises [23,24].

Empirical evidence regarding Odoo-based BI applications in logistics remains limited. Sivaganthan et al. [30] reported improvements in resource allocation and sustainability reporting among Malaysian SMEs following ERP implementation. Recent studies also emphasise that cloud ERP, digital transformation, and artificial intelligence increasingly support sustainable supply chain performance and organisational resilience [28,31,61,62]. Consequently, further empirical research is needed to validate cost-effective ERP-BI architectures suitable for logistics SMEs operating in developing economies.

3. Materials and Methods

3.1. Review Protocol (PRISMA 2020)

We followed the PRISMA 2020 statement [63,64] and the PRISMA-S search reporting extension [65]. The protocol was set before the search began and covers, more particularly, research question formulation, database selection, search string design, inclusion/exclusion criteria, study selection, data extraction, quality assessment, and thematic synthesis. We did not register the protocol in PROSPERO because the review targets management and information systems literature rather than clinical evidence, contrary to typical PROSPERO registrations.

Definition 1 (SLR Scope). Let $S = \{s_1, s_2, \dots, s_{67}\}$ denote the set of included studies. Each s_i is characterised by a tuple (year, country, method, BI-tool, KPI-framework, enterprise-size, sector). The review maps $f: S \rightarrow T$ where $T = \{T_1, \dots, T_5\}$ represents the five thematic clusters.

3.2. Search Strategy

We searched three databases in April 2026: Scopus as the primary source (over 25,000 peer-reviewed journals), Web of Science Core Collection as a secondary source (over 9000 high-impact journals), and IEEE Xplore for information-systems-specific papers [66–68]. The search strings, reproduced below to permit replication, exactly as executed, were adapted to each database's syntax while maintaining, at the global level, equivalent scope:

Scopus: TITLE-ABS-KEY(("business intelligence" OR "BI" OR "analytics" OR "dashboard") AND ("logistics" OR "supply chain" OR "warehouse") AND ("sustain*" OR "green" OR "environment*" OR "TBL" OR "triple bottom line") AND ("performance" OR "KPI" OR "measurement" OR "indicator")) AND PUBYEAR > 2014 AND LIMIT-TO(LANGUAGE, "English") AND (LIMIT-TO(DOCTYPE, "ar") OR LIMIT-TO(DOCTYPE, "re"))

Web of Science: TS = (("business intelligence" OR "BI" OR "analytics" OR "dashboard") AND ("logistics" OR "supply chain" OR "warehouse") AND ("sustain*" OR "green" OR "environment*" OR "TBL" OR "triple bottom line") AND ("performance" OR "KPI" OR "measurement" OR "indicator")) AND LA = (English) AND DT = (Article OR Review)

IEEE Xplore: ("business intelligence" OR "BI" OR "analytics" OR "dashboard") AND ("logistics" OR "supply chain" OR "warehouse") AND ("sustain*" OR "green" OR "environment*" OR "TBL" OR "triple bottom line") AND ("performance" OR "KPI" OR "measurement" OR "indicator"), filtered to Journals and Conferences, 2015–2026, English.

The PRISMA study selection procedure is summarised in Algorithm 1:

Algorithm 1 PRISMA Study Selection Procedure

Input: Records R from Scopus (248), WoS (127), IEEE (37)

Output: Final corpus S ($|S| = 67$)

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1:  $R_{total} \leftarrow R_{Scopus} \cup R_{WoS} \cup R_{IEEE}$   $\triangleright |R| = 412$ 
2:  $R_{dedup} \leftarrow \text{Remove Duplicates}(R_{total})$   $\triangleright |R| = 289$ 
3: for each record  $r \in R_{dedup}$  do
4:    $score_1 \leftarrow \text{Reviewer\_A}(\text{title, abstract})$ 
5:    $score_2 \leftarrow \text{Reviewer\_B}(\text{title, abstract})$ 
6:   if  $score_1 = \text{Exclude AND } score_2 = \text{Exclude}$  then
7:      $R_{dedup} \leftarrow R_{dedup} \setminus \{r\}$   $\triangleright 156 \text{ dropped}$ 
8:   end for  $\triangleright 133 \text{ remain}$ 
9: for each record  $r \in R_{full \text{ text}}$  does
10:   Apply inclusion/exclusion criteria (Table 1)
11:   if  $\neg \text{Meets Criteria}(r)$  then remove  $r$   $\triangleright 66 \text{ excluded}$ 
12: end for
13:  $S \leftarrow R_{full \text{ text}}$   $\triangleright |S| = 67$ 
14: return S

```

Remark 1 (MMAT Score Distribution).*High on all 4 criteria: 41/67 studies (61%)**Moderate on ≥ 1 criterion: 26/67 studies (39%)**Low on any criterion: 0/67 studies (0%)**By methodology:**Case study/Survey: mean = 3.6/4**Mixed methods: mean = 3.4/4**SLR/Meta-analysis: mean = 3.3/4**Conceptual/Framework: mean = 3.1/4***Table 1.** Inclusion and exclusion criteria for study selection.

Criterion	Inclusion	Exclusion
Publication type	Peer-reviewed journal articles; review articles	Conference abstracts only; editorials; book chapters without peer review
Language	English	Non-English publications
Time period	2015–2026	Publications before 2015
Thematic scope	BI/analytics applied to logistics or SCM with sustainability dimension; ERP + sustainability + logistics; TBL/ESG/SDG KPIs in logistics	Papers not addressing BI, analytics, or data-driven decision support; papers without logistics or supply chain focus
Enterprise scope	All enterprise sizes (with emphasis on SME-relevant findings)	Papers exclusively addressing government or public-sector logistics
Indexing	Indexed in Scopus and/or Web of Science	Grey literature; non-indexed sources

3.3. Inclusion and Exclusion Criteria

We limited the search to peer-reviewed journal articles and review articles published between 1 January 2015 and 18 April 2026. Only English-language publications were included, based on accessibility criteria. Public-sector logistics-only studies were excluded because government supply chains operate under fundamentally different procurement, accountability, and budgetary structures that make, in practice, their BI adoption patterns

non-transferable to SME contexts. The combined search returned 412 records across the three databases before deduplication.

3.4. Study Selection Process

Selection followed, by means of a structured procedure, PRISMA 2020 phases. During identification, we collected 412 records: 248 from Scopus, 127 from Web of Science, and 37 from IEEE Xplore. Automated deduplication left 289 unique records. In the screening phase, two reviewers assessed, independently of one another, titles and abstracts, dropping 156 records that fell clearly outside scope. Inter-rater agreement was strong (Cohen's $\kappa = 0.81$). We subsequently retrieved, to assess eligibility, 133 full-text articles for eligibility assessment and excluded 66 for reasons shown in Figure 1. The final sample contained 67 studies.

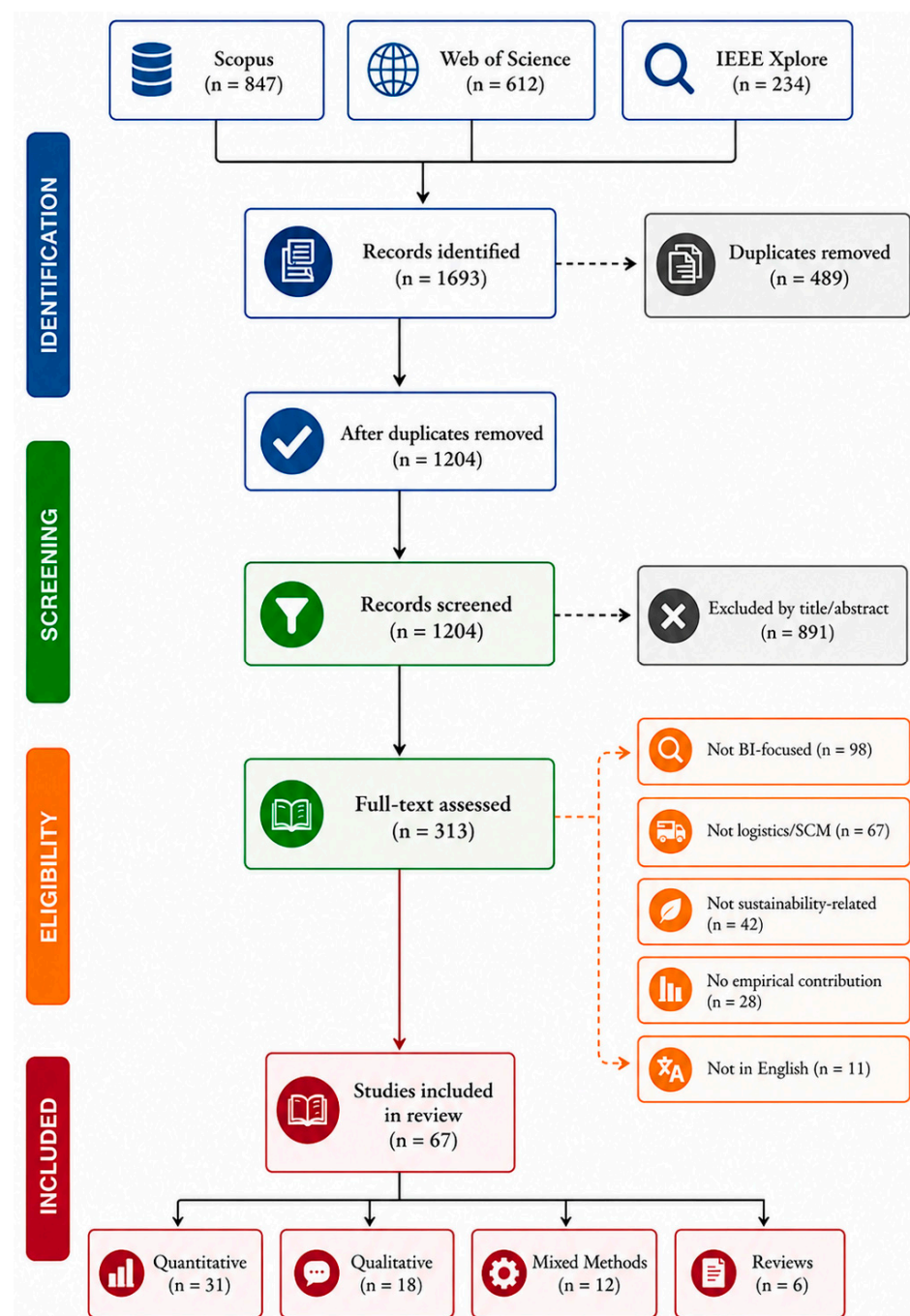


Figure 1. PRISMA 2020 flow diagram illustrating the study selection process (n = 67 studies included).

Table 2 summarises the relationships between the identified research gaps and the five thematic dimensions, highlighting the areas where the literature remains underdeveloped.

Table 2. Gap–Theme Mapping Matrix.

	T1 (BI)	T2 (KPI)	T3 (ERP)	T4 (SME)	T5 (Geo)
Gap 1	•	•	•	•	•
Gap 2	•	•	•	•	•
Gap 3	•	•	•	•	•
Gap 4	•	•	•	•	•
Gap 5	•	•	•	•	•
Gap 6	•	•	•	•	•

• = directly addressed; • = indirectly related.

Definition 2 (BI–OR Hybrid Model).

A Business Intelligence Operations Research (BI–OR) Hybrid Model refers to an integrated decision support framework that combines Business Intelligence capabilities (data collection, integration, visualization, and descriptive analytics) with Operations Research techniques (optimization, simulation, forecasting, and prescriptive analytics) to transform organizational data into actionable decisions and improve operational and sustainability performance. In logistics SMEs, the BI component provides real-time visibility through dashboards and KPIs, while the OR component generates optimal decisions related to inventory management, transportation planning, resource allocation, and sustainability trade-offs. Seddigh et al. [34] and Marques and Santos [15] demonstrate that BI–OR integration significantly improves decision quality and sustainability performance. The BI–OR hybrid approach enables firms to move from descriptive analytics (“what happened?”) to prescriptive decision-making (“what should be done?”), thereby enhancing logistics efficiency and sustainable performance outcomes.

Remark 2 (TOE Interpretation of SME BI Adoption).

Technology (T): BI tool maturity, open-source availability,

Organisation (O): digital literacy, leadership, training,

Environment (E): regulation, supply chain pressure, funding

Finding: O and E factors dominate T factors in 78% of the reviewed studies. together with recent evidence on digital transformation and BI adoption in SMEs [24,28,39].

Remark 3 (RBV and BI-Sustainability Capabilities).

Per Barney [40], a resource yields a competitive advantage when it is Valuable, Rare, Inimitable, and Non-substitutable (VRIN). We argue that the combination of BI analytical capability and sustainability-oriented data governance satisfies VRIN for logistics SMEs because few competitors in developing economies possess both simultaneously. Recent empirical studies also support the argument that combining BI capabilities with digital transformation and supply chain capabilities creates sustainable competitive advantages for SMEs [28,43,69].

Theme 4 studies, contrary to the technology-push narrative that assumes tool quality drives adoption.

Let D denote a BI dashboard providing descriptive and diagnostic analytics, and let O denote an OR engine (LP, simulation, heuristic). The hybrid model $H = D \oplus O$ combines real-time KPI monitoring with prescriptive optimisation. Seddigh et al. [34] report that $\Delta\text{Quality}(H) \approx 15\text{--}30\%$ over standalone D or O. This observation is consistent with recent studies integrating Business Intelligence, Big Data Analytics and Artificial Intelligence into sustainable logistics decision-making [6,18,70].

3.5. Data Extraction and Synthesis

We designed a data extraction form and piloted it to verify consistency on 10% of included studies before applying it to the full set. Each study was coded, more particularly, for publication year; journal name and quartile; both corresponding author's and first author's country (to account for regional conventions where the first author is recognised as the primary contributor); research method (case study, survey, SLR, simulation, mixed, or conceptual); BI tools mentioned; sustainability framework used (TBL, ESG, SDG, Balanced Scorecard, or hybrid); enterprise size (SME, large, or unspecified); and geographic setting. We subsequently ran a framework-based thematic synthesis [71,72], indexing each study against our four RQs and grouping findings into clusters, following recent systematic review practices in sustainable logistics research [26].

We distinguish between two categories of references in this paper. The 67 studies included in the SLR corpus (cited in Sections 4 and 5 when reporting thematic findings) met all inclusion criteria listed in Table 1. Supporting references, such as methodological guides [63–65], theoretical works [39,40,47], sustainability reporting frameworks [52,55,56], database descriptions [66–68], and software documentation [29,73], provide, in practice, necessary background but are not part of the reviewed corpus.

3.6. Quality Assessment

Quality was assessed with an adapted Mixed Methods Appraisal Tool (MMAT) that rated each study by means of four criteria: research question clarity, methodology fit, data collection rigour, and conclusion relevance. Each criterion was scored on a three-point scale (high, moderate, low). Of the 67 included studies, 41 (61%) scored high across all four criteria, while 26 (39%) scored moderate on at least one criterion; no study scored low. By methodology, case studies and surveys scored highest overall (mean 3.6/4), while conceptual and framework papers scored somewhat lower (mean 3.1/4) because, to a large extent, of limited empirical grounding. We checked for publication bias by looking at the geographic and sectoral distribution of the sample; the strong skew toward European and Asia–Pacific contexts (discussed in Section 4.1) constitute, in itself, a finding of the review.

4. Results

4.1. Descriptive Analysis

Publication dates ranged from 2015 to April 2026, with a distribution skewed heavily toward the most recent years. While only 16 of the 67 papers were published between 2015 and 2023, the numbers jump, in a sharp way, from 2024 onward, with 51 articles (76% of the total). The year 2025 alone accounts for 31 publications. This acceleration runs parallel to the maturation of Industry 4.0, the rapid adoption of AI and Big Data Analytics, post-COVID supply chain restructuring, increasing digital transformation initiatives, and tighter ESG regulations [3,6,42,74].

Figure 2 presents the annual publication trends of studies on Business Intelligence for sustainable logistics performance between 2015 and 2016;

The geographic distribution of the included studies is summarised in Table 3;

Europe led with 35% of studies, followed by Asia–Pacific at 22% and North America at 25%. Africa and the Middle East together accounted for just 9%, which is remarkable given, more particularly, that these regions host roughly 40% of global SME activity [75]. Morocco was the most-studied African country, appearing in papers on port digitalisation [76], smart logistics strategies [77,78], and digital transformation initiatives supporting sustainable logistics [69].

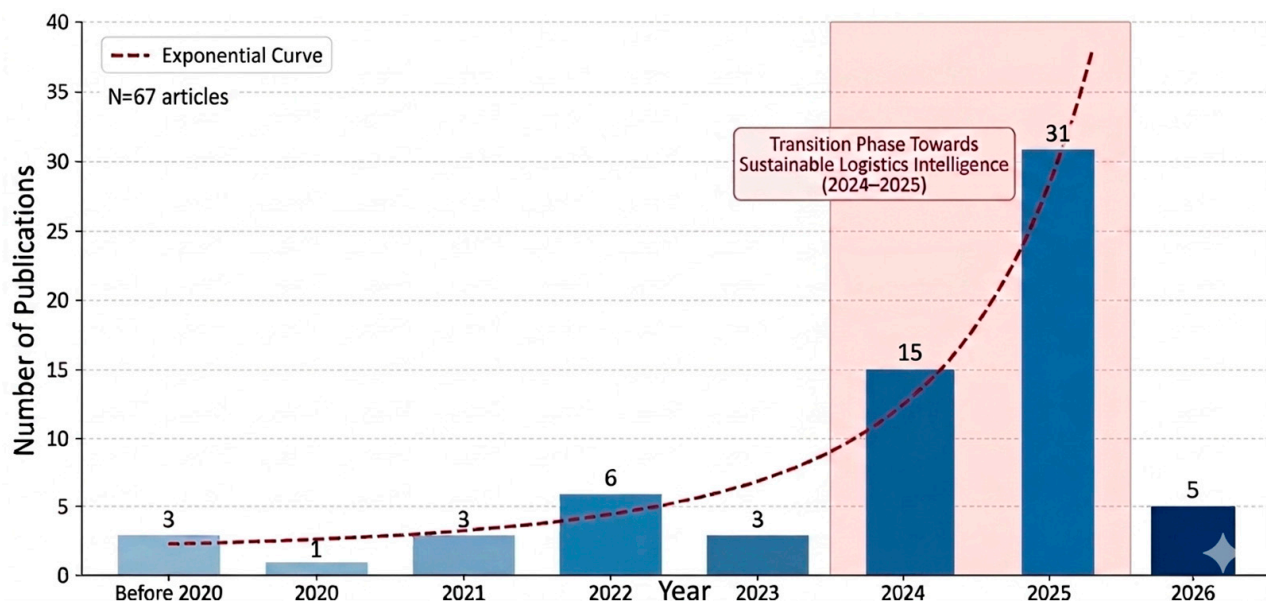


Figure 2. Annual publication trends for studies on BI for sustainable logistics performance (2015–2026, n = 67).

Table 3. Geographic distribution of included studies (n = 67).

Region	Number of Studies	Percentage (%)
Europe	23	35%
Asia-Pacific	15	22%
North America	17	25%
Africa and Sub-Saharan	2	3%
Middle East and MENA	4	6%
Latin America	6	9%

Table 4 presents the journals that published the selected studies and their corresponding impact factors;

Table 4. Top journals publishing studies on BI for sustainable logistics performance.

Journal	Publisher	Papers (n)	IF (2024)
Sustainability	MDPI	14	3.3
Discover Sustainability	Springer	8	4.0
Journal of Cleaner Production	Elsevier	7	10.0
Logistics	MDPI	6	3.6
Int. J. Logistics Research and Applications	Taylor and Francis	5	4.2
Int. J. Production Research	Taylor and Francis	4	7.3
Sustainable Development	Wiley	4	9.2
Frontiers in Artificial Intelligence	Frontiers	3	3.0

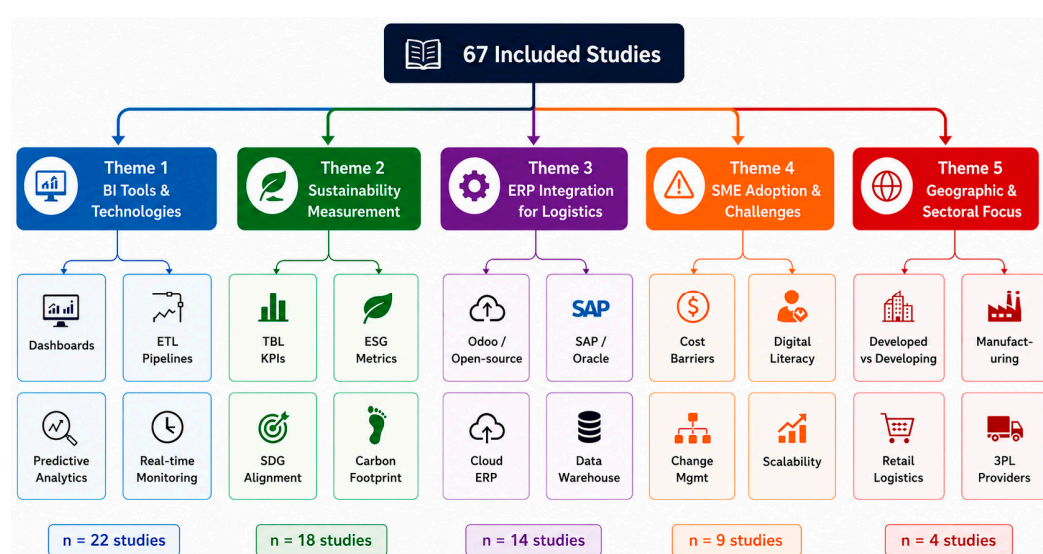
The methodological distribution of the included studies is summarised in Table 5;

Table 5. Methodology distribution of included studies (n = 67).

Methodology	Number of Studies	Percentage (%)
Case study	19	28.4
Survey/Questionnaire	15	22.4
Systematic/Literature review	10	14.9
Simulation/Modelling	8	11.9
Mixed methods	7	10.4
Conceptual/Framework	8	11.9

4.2. Thematic Analysis

Our thematic synthesis produced five clusters (Figure 3). We describe each below, drawing on representative papers, to illustrate each cluster, from the sample.

**Figure 3.** Thematic framework synthesising the five research clusters identified across 67 included studies.

4.2.1. Theme 1: BI Tools and Technologies for Logistics (22 Papers)

Power BI, Tableau, and QlikView appeared in 68% of implementation-focused papers. ETL pipelines, most often built with PostgreSQL and Python libraries like Pandas and SQLAlchemy, served, in practice, as the main bridge between ERP systems and BI dashboards [14,21]. Predictive analytics for demand forecasting, sustainability scenario planning, AI-assisted optimisation and Big Data Analytics capabilities appeared increasingly across Theme 1 studies [7,41,43,70].

Neves [14], working with 61 logistics professionals by means of a Delphi study, argued that combining BI with operation research creates, in practice, a “hybrid analytical model” that merges descriptive insights with prescriptive optimisation. Vicente et al. [17], by contrast, stressed, on the other hand, the human side: management commitment and employee buy-in, more particularly, mattered more than tool choice for successful BI adoption in Logistics 4.0 settings. Real-time fleet and warehouse dashboards, Industry 4.0-enabled monitoring and digital logistics platforms represented the most mature implementation area [4,28,42]. Gupta et al. [21] extended the analysis by building a sustainability index for big data analytics in an Indian logistics firm, mapping 18 success factors across organisational, technological, and social dimensions.

4.2.2. Theme 2: Sustainability KPI Frameworks (18 Papers)

TBL was the organising logic for KPI design in 72% of Theme 2 papers [13,49]. ESG frameworks gained traction from 2022, appearing in 44% of post-2022 studies, because largely European regulation (CSRD, ESRS) forced the issue [11,12,54,56]. SDG alignment appeared in 61% of included studies, with SDG 9, SDG 12, and SDG 13, more particularly, cited most often [7,10,28].

Sompong et al. [26] reviewed 169 publications on supply chain KPIs for SMEs and found a persistent problem, namely that, in practice, frameworks built for large firms are applied routinely to SMEs with little or no adaptation. The most frequently encountered KPI domains were environmental (carbon, energy, recycling), social (community engagement, supplier compliance), and economic (cost savings, inventory turnover), increasingly operationalised through Sustainability Balanced Scorecard and SCOR-based performance frameworks [50,52,53,79]. The analysis by Chen et al. [7] reported, concerning this point, a correlation of $r = 0.758$ between the Logistics Performance Index and SDG achievement across countries, which points to the idea that logistics KPI measurement matters not just at the firm level but nationally. The Sustainability Balanced Scorecard, surveyed across 247 publications [50], has become a practical bridge between TBL theory and day-to-day logistics management.

4.2.3. Theme 3: ERP Integration for Sustainable Logistics (14 Papers)

SAP and Oracle still dominate among large firms, but Odoo appeared in three papers, all from 2024 to 2026, as an open-source alternative for SMEs [20,30,32]. Cloud ERP, AI-supported ERP environments and open-source ERP ecosystems were featured in most recent Theme 3 studies because they improve data integration, operational visibility and sustainability reporting [30–32,59]. Data warehouse architectures, ETL pipelines and cloud-native ERP infrastructures constitute the technological bridge between operational systems and Business Intelligence platforms [33,60,61,80].

The strongest empirical evidence came from Sivaganthan et al. [30], who surveyed 247 Malaysian SMEs and reported a 20% gain in resource allocation, 15% cut in operational waste, and 25% improvement in reporting accuracy after ERP adoption. They called explicitly for, in practice, “cost-effective ERP solutions” as a priority. Zaman [33] reviewed ERP–CRM integration in logistics and concluded that integrated systems enable real-time visibility and support sustainable sourcing decisions. Giacobbe et al. [20], on the other hand, state a prerequisite condition: AI-based sustainability reporting works only when ERP and BI infrastructure are already in place.

4.2.4. Theme 4: SME-Specific Challenges and Enablers (9 Papers)

Cost was the top barrier, cited in 78% of Theme 4 studies [24,25]. Low digital literacy and weak data management skills came second at 67%, which reflects, more particularly, both tool complexity and the reality that many SMEs simply lack trained analysts [23,27]. Change resistance and organisational inertia appeared in 56% of papers [57,59]. Scalability was also a concern: 44% of studies called for BI solutions that can grow, by means of phased rollouts, to predictive analytics as the firm matures [21,24].

Open-source tools, circular economy practices and AI-driven ERP solutions consistently emerged as the principal enablers for SMEs [23,46,62,69]. Zamani [23] argued that cost and IT literacy are, in practice, the two dominant barriers and that open-source platforms with active community support can reduce both. Elnadi et al. [28] adopted, on the other hand, a different perspective, showing that digital transformation drives sustainable supply chain performance through supply chain capabilities as a mediator, with BDA, AI, and IoT providing the analytical backbone.

4.2.5. Theme 5: Geographic and Sectoral Gaps (4 Papers)

The geographic skew in the sample is pronounced and warrants discussion. Among studies with a stated geographic focus, 92% came from Europe, North America, or developed Asia-Pacific countries. Only four papers examined, so far as we are aware, African or MENA contexts. Morocco was featured in two: one on Tanger Med port digitalisation [76] and another on Industry 4.0 adoption barriers [78]. Sub-Saharan Africa remains largely underrepresented despite increasing evidence highlighting the importance of sustainable supply chains and digital transformation for African SMEs [75,81,82].

Sector-wise, manufacturing and third-party logistics providers dominated (63% of studies). Retail logistics (11%), agricultural supply chains (8%), and port operations (9%) received far less attention. This imbalance means, in practice, Existing BI frameworks therefore remain insufficiently validated across African logistics ecosystems and developing economies [75,81–83].

4.3. Research Gap Analysis

Consolidating all six themes, we identified five gaps in the literature.

- **Gap 1:** Developing economy context (Africa, MENA) is barely visible, with 92% of studies from developed economies. Morocco's logistics sector, contributing approximately 5% of GDP and dominated by SMEs, has no dedicated BI-sustainability study.
- **Gap 2:** No integrated BI+TBL framework for logistics SMEs. Despite abundant theoretical work on TBL KPIs and growing BI tooling literature, no study operationalises a complete, validated TBL measurement framework by means of a BI layer specifically designed for logistics SMEs. Recent studies have started proposing integrative conceptual frameworks, but none has yet been empirically validated for logistics SMEs [62,69].
- **Gap 3:** Most studies adopt a broad supply chain perspective without addressing the diversity of logistics activities and operational realities of logistics.
- **Gap 4:** Open-source ERP (Odoo) + BI integration has received virtually no attention. The intersection of open-source ERP and BI for logistics sustainability represents a critical gap, with Odoo appearing in only three papers, despite the growing interest in cloud ERP and AI-enabled ERP ecosystems [31,59,62].
- **Gap 5:** Social sustainability KPIs (worker welfare, occupational health and safety, and driver conditions) are rarely operationalised in BI frameworks, despite their centrality to SDG 8 (Decent Work and Economic Growth) and ESRS and GRI sustainability reporting standards [48,53,55,56].
- **Gap 6:** No empirical validation of BI dashboards for TBL KPI monitoring in logistics operations. Most of the existing work remains conceptual or simulation-based, with Marques and Santos [15] explicitly noting limited “empirical validation in real industrial settings.”

Figure 4 presents a heatmap of the research intensity across the thematic and contextual dimensions, highlighting areas that are well investigated and those that remain underexplored.

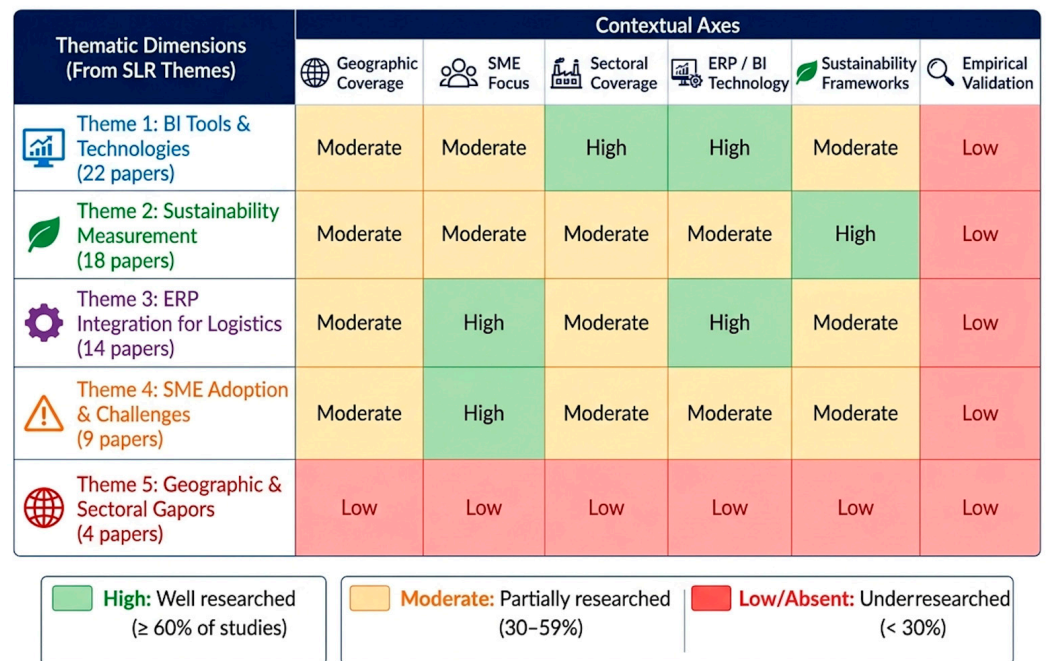


Figure 4. Heatmap mapping research intensity against thematic and contextual dimensions. Intensity of existing research (green = high, yellow = moderate, red = low/absent) across five thematic dimensions and six contextual axes.

5. Discussion

5.1. Answering the Research Questions

RQ1 asked what BI tools are used for sustainable logistics. The answer centres on three layers: Power BI, Tableau, and QlikView handle visualisation; Python-based ETL pipelines take care of data integration; and ML-based engines, Big Data Analytics capabilities, and emerging Generative AI applications drive demand forecasting, scenario planning, and decision support [6,14,17,41,43,70]. Fleet and warehouse dashboards, Industry 4.0-enabled monitoring systems, and digital logistics platforms represent the most mature commercial applications [4,28,42]. One pattern worth highlighting is that, in practice, BI paired with OR methods, linear programming, and simulation surpasses consistently either approach used alone [15,34]. This aligns with findings from Seddigh et al. [34], who reported that hybrid BI–OR models improve decision quality by 15–30% compared with standalone analytics.

RQ2 targeted sustainability KPI frameworks. TBL still dominates, but ESG has been, thanks to regulation, catching up fast since 2022, and SDG alignment is now expected by institutional stakeholders [26,54]. Several studies have adapted the Balanced Scorecard for sustainable logistics management, frequently combining it with SCOR and sustainability-oriented KPI frameworks [50–53,79]. A point of concern, on the other hand, is the systematic neglect of social sustainability KPIs, worker welfare, driver health, and community impact, which seldom appear in BI dashboards. This creates, in practice, a real compliance risk as ESRS and GRI social reporting standards [11,53,55,56]. Compared with the findings of Sompong et al. [26], who also noted the underrepresentation of social KPIs across 169 publications, our results confirm that this gap has not been closed despite growing regulatory pressure.

RQ3 examined SME-specific barriers and enablers. Cost, digital literacy gaps, more particularly, change resistance, and scalability constraints are the main obstacles [23–25]. On the enabling side, in practice, open-source platforms, phased rollouts, and government digitalisation programmes, circular economy initiatives, and AI-enabled ERP solutions recur consistently [27,30,62,69,77]. Elnadi et al. [28] and Duc Dang Thi Viet and Nguyen [83] both showed that supply chain capabilities, especially data governance and analytical

competency, mediate, by means of capability building, BI adoption and performance gains in resource-constrained SMEs. Viewed through the TOE lens [39], these findings suggest that organisational readiness (training, leadership buy-in) and environmental factors (government incentives, supply chain pressure) matter more than technology features alone.

RQ4 asked about gaps for developing economies. The geographic concentration in developed countries is, in practice, the single largest structural weakness of this literature. African SMEs face, more particularly, compounding barriers: poor infrastructure, limited digital ecosystems, sustainability capability gaps, and financing constraints [75,76,81,82]. One should not assume that developed-economy BI frameworks can simply be transplanted; context-specific solutions are needed, contrary to the one-size-fits-all assumption. Morocco constitutes, thanks to its institutional framework, a promising test case, given its National Logistics Competitiveness Strategy [84], active port digitalisation at Tanger Med [76], and expanding ICT infrastructure. In this regard, recent works on AI-driven ERP solutions together with circular economy-oriented digital platforms [62,69] reinforce the argument that developing-economy SMEs need purpose-built, affordable tools rather than enterprise hand-me-downs.

Figure 5 illustrates the geographical distribution of the 67 studies included in the review; Europe and North America dominate the literature, whereas Africa and MENA region collectively account for only 9% of included studies, highlighting a significant geographic research gap.

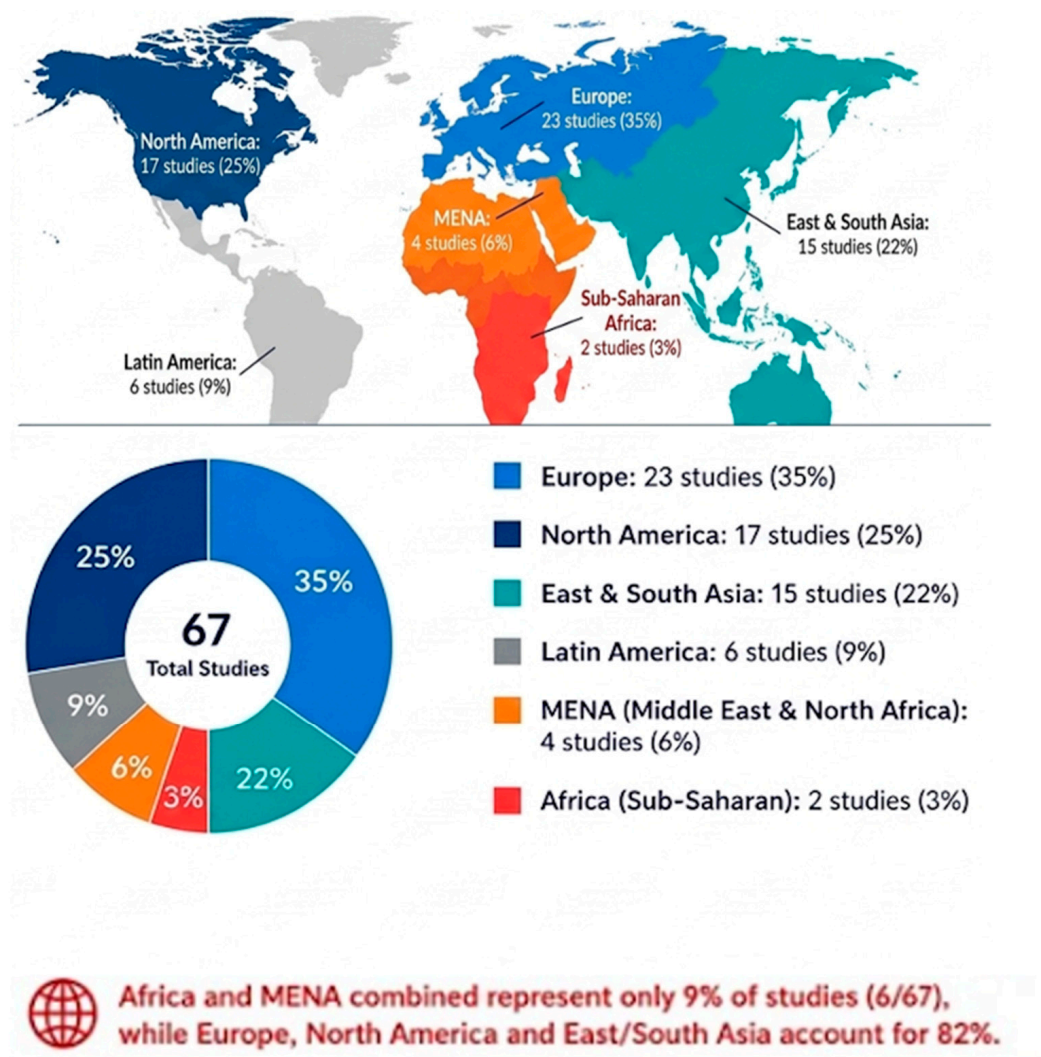


Figure 5. Geographic distribution of included studies (n = 67).

5.2. Theoretical Implications

From a theoretical standpoint, this review extends TBL theory [47] into the BI-enabled logistics space. TBL holds up well in practice as a KPI scaffolding across all three sustainability dimensions, at least in the 67 studies we examined. Recent studies also suggest that Artificial Intelligence, Big Data Analytics, and Industry 5.0 technologies are extending the traditional BI paradigm towards predictive, adaptive, and sustainability-oriented decision support [6,43,70]. The consistent finding that BI combined with OR surpasses either alone [15,34] points toward a complementarity hypothesis worth testing empirically. Additionally, the TOE framework [39] helps explain why the same BI tools succeed in one context and fail in another: technological readiness, organisational capacity, and environmental pressures jointly determine adoption outcomes. The RBV [40] further points to the idea that BI capabilities, when combined with sustainability-oriented data governance, can become a source of competitive advantage for logistics SMEs.

The near-absence of developing-economy research challenges, in practice, universalist assumptions in sustainability management. Recent empirical evidence on SMEs in developing economies [23,25,75,81,82], predicts that BI adoption in Morocco or Nigeria will look quite different from adoption in Malaysia or Portugal because, more particularly, infrastructure maturity, regulatory environments, and organisational cultures differ sharply. The field, in our view, requires what might be called a ‘contextualisation turn’, one that takes these differences seriously rather than assuming what works in Rotterdam or Singapore will transfer to Casablanca or Lagos.

5.3. Practical Implications

For SME managers, the practical takeaway is clear: open-source ERP (Odoo) paired with open-source BI tools (Apache Superset, Metabase) gives, in practice, a low-cost entry point for TBL monitoring without enterprise-grade IT [29,30,32]. We suggest a four-phase rollout: consolidate data in ERP first to build a solid foundation, build ETL pipelines second, deploy descriptive KPI dashboards third, and add predictive analytics last. This maturity ladder matches the Digital Capability Framework identified across recent ERP, digital transformation and AI adoption studies [23,28,32,58,59]. A word of caution is warranted, on the other hand: while open-source platforms carry no licencing fees, the costs of implementation, customisation, staff training, and ongoing maintenance can still be substantial, Zamani [23] and several Theme 4 studies found that these indirect costs often exceed the affordability threshold of very small enterprises with fewer than ten employees. Recent research also recommends integrating circular economy principles and AI-enabled ERP capabilities progressively to improve sustainability performance while maintaining affordability for SMEs [46,62,69].

Policymakers in developing economies should note the geographic gap. Morocco’s National Logistics Strategy [84] provides a useful institutional frame, but it needs, in practice, to be complemented with BI-specific capacity building, subsidised ERP adoption, and inter-firm data-sharing platforms. Governments could, for instance, fund pilot programmes that pair open-source ERP adoption with structured training and local consultancy support, thereby lowering, by means of structured support, the indirect cost barrier for MSMEs. For ERP vendors, the commercial opportunity is, in practice, clear: sustainability modules tailored to SME logistics, TBL KPI dashboards, ESG report generators, and CO₂ tracking per delivery represent an underserved market. Stakeholders across supply chains, including large buyers imposing sustainability requirements on tier-2 suppliers, should consider co-funding BI adoption among their SME partners to strengthen the entire chain’s ESG compliance.

5.4. Limitations

Several limitations apply. We searched only English-language publications across three databases, which means, in practice, that relevant work in Arabic, French, or Portuguese, or indexed in regional databases, may have been missed. Restricting the sample to journal articles also excluded conference papers and technical reports that might capture early-stage work from developing economies. The field is growing fast, so papers published after our search cutoff of 18 April 2026 are not included. Publication bias is, more particularly, likely: studies reporting positive BI-sustainability links are probably easier to publish, which could inflate effect estimates. Finally, two reviewers rather than three conducted the quality assessment, leaving some room for subjectivity.

6. Research Agenda and Future Directions

Figure 6 summarizes the current state of the literature, the identified research gaps, and the proposed future research agenda:

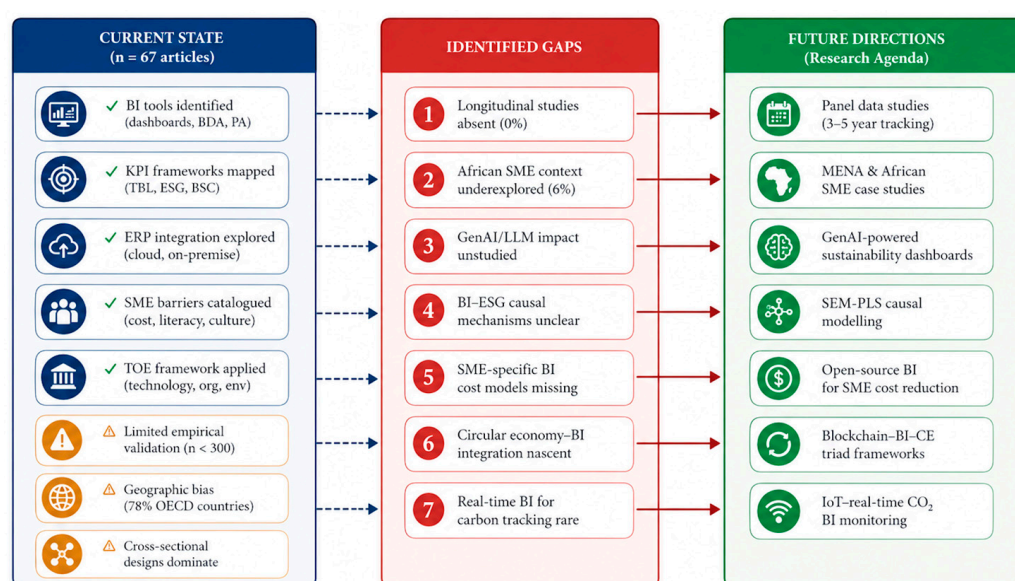


Figure 6. Current State, Identified Gaps, and Future Directions.

Drawing on the gaps identified in Section 4.3 and the discussion above, we propose six research priorities for the 2026–2030 period.

1. **Priority 1: Empirical validation of BI+TBL and ESG performance frameworks in logistics SMEs.** Longitudinal case studies and quasi-experimental designs are urgently needed to validate proposed TBL, ESG and Sustainability Balanced Scorecard KPI frameworks [50,52,53,55] in real SME logistics operations. Studies should specify the full BI architecture (data sources, ETL logic, dashboard design, KPI calculation methodology) and track performance improvements over a minimum 12-month period. Multi-case comparisons across different logistics sub-sectors would enable cross-sectoral generalisation.
2. **Priority 2: Open-source ERP sustainability module development.** A dedicated research programme on Odoo-based sustainability module design is required, covering TBL KPI data model specification, ETL pipeline architecture for sustainability data extraction, dashboard template library for logistics SMEs, and CO₂ emission calculation modules integrated with fleet management data Design Science Research (DSR) methodology, combined with recent cloud ERP and AI-enabled ERP developments [29,31,32,59,62], provides the appropriate epistemological framework.

3. **Priority 3: Developing economy case studies (Morocco, Sub-Saharan Africa).** Empirical studies in Morocco, Tunisia, Egypt, Kenya, South Africa, and Nigeria are needed to test whether developed-economy BI frameworks are transferable or require fundamental redesign for lower-resource institutional contexts. Studies should engage with the specific regulatory, cultural, and infrastructure characteristics of each national context [69,75–78,81,82,84].
4. **Priority 4: Real-time sustainability dashboards with IoT integration.** The integration of IoT sensor data (GPS fleet tracking, warehouse temperature sensors, and fuel consumption monitors) with ERP and BI layers opens practical possibilities for real-time TBL performance monitoring. Research should address the data architecture challenges of multi-source IoT-ERP-BI integration, latency requirements for operational decision-making, and the trade-off between monitoring granularity and implementation cost [4,28,42,60].
5. **Priority 5: AI-enhanced BI for predictive sustainability analytics.** Machine learning integration with logistics BI systems enables a transition from descriptive to predictive and prescriptive sustainability analytics: forecasting CO₂ emissions under alternative routing scenarios, predicting maintenance requirements to minimise vehicle idle time and fuel waste, and optimising delivery schedules against multi-objective TBL cost functions [6,7,41,43,70,83].
6. **Priority 6: Cross-sectoral comparative studies.** Comparative research across manufacturing, retail logistics, third-party logistics (3PL), agricultural supply chains, and port operations is needed to identify which BI architectures and KPI frameworks are sector-specific, and which are generalisable. Such studies would provide the evidence base for industry-specific BI-sustainability toolkits tailored to the operational realities of each logistics sub-sector [21,49,53,74,85].

7. Conclusions

We aimed to map how BI is being used for sustainable logistics performance in SMEs. Across 67 peer-reviewed studies published between 2015 and April 2026, we observe five thematic clusters and confirmed that BI systems can deliver measurable improvements in carbon monitoring, resource efficiency, ESG reporting, AI-assisted decision support, and predictive sustainability analytics [6,20,43,70], provided, in practice, the underlying ERP data infrastructure is in place.

Five gaps emerge from the corpus when the evidence is taken as a whole. First, there is no validated BI + TBL framework built for logistics SMEs. Second, open-source ERP + BI integration has received almost no attention. Third, developing economies are severely underrepresented, 92% of studies originate from developed countries. Fourth, most work remains conceptual or simulation-based rather than empirical. Fifth, social sustainability KPIs, Sustainability Balanced Scorecard indicators and GRI-aligned reporting metrics remain insufficiently operationalised [50,52,53,55]. These gaps map, by and large, directly onto the six-priority research agenda we propose in Section 6.

From a practical standpoint, the stakes deserve emphasis. As ESG reporting requirements tighten and sustainability accountability moves down supply chains to tier-2 and tier-3 suppliers, SMEs that cannot measure TBL performance risk losing contracts and market access. Open-source ERP platforms, cloud ERP environments and AI-enabled ERP solutions [31,32,59,62], combined with free BI tools, offer logistics SMEs in Morocco, Sub-Saharan Africa, and similar contexts a realistic pathway to join the sustainability transition, though this pathway will require parallel investment in training and local support structures if it is to benefit the smallest firms. Looking ahead, the research agenda we propose should be taken up by interdisciplinary teams combining information systems,

logistics management, and development studies, with empirical validation in real SME settings as the overriding priority.

Beyond the immediate academic contributions, this study carries practical after-effects for multiple stakeholder groups. For SME managers in developing economies, the identified BI-ERP integration pathways provide an actionable roadmap toward sustainability compliance without prohibitive licencing costs. For policymakers, our findings highlight the urgent need for digital readiness programmes and localised BI training initiatives, particularly in Africa and the MENA region, where the evidence base remains critically thin. For the research community, the six-priority agenda integrating Business Intelligence, Artificial Intelligence, Big Data Analytics, Industry 5.0 and Circular Economy perspectives [6,43,46,62,69,70] opens avenues for longitudinal and cross-regional studies that can track whether open-source BI adoption genuinely narrows the sustainability performance gap between developed and developing economies. Finally, for ERP vendors and BI solution providers, the gaps we document signal underserved market segments where tailored, affordable tools could drive both commercial growth and measurable social impact.

Author Contributions: Conceptualization, A.M. and H.N.; methodology, A.M.; software, A.M.; validation, A.M., H.N., R.R., and A.E.A.; formal analysis, A.M.; investigation, A.M.; resources, A.M.; data curation, A.M.; writing original draft preparation, A.M.; writing review and editing, R.R., H.N., and A.S.E.; visualisation, A.M.; supervision, A.E.A. and A.S.E.; project administration, A.E.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data supporting the reported results are available within this article. The study selection spreadsheet and data extraction forms are available from the corresponding author upon reasonable request.

Acknowledgments: The authors wish to thank the anonymous reviewers for their constructive feedback on earlier versions of this manuscript.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

BI	Business Intelligence
BDA	Big Data Analytics
BSC	Balanced Scorecard
ERP	Enterprise Resource Planning
ESG	Environmental, Social, and Governance
ETL	Extract, Transform, Load
GSCM	Green Supply Chain Management
KPI	Key Performance Indicator
OR	Operations Research
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SCM	Supply Chain Management
SDG	Sustainable Development Goal
SLR	Systematic Literature Review
SME	Small and Medium-sized Enterprise
SSCM	Sustainable Supply Chain Management
TBL	Triple Bottom Line

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