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Article

A Decision-Support Framework for Human-Centric and Sustainable Logistics 5.0

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Abstract: Logistics 5.0 is a new paradigm that combines eco-friendly development, organizational readiness for transformation, and human–machine collaboration to accommodate the rapid transformation of logistics systems provoked by digitalization, sustainability requirements, and human-centered development beyond the automation-oriented Logistics 4.0. Although advanced technologies and green logistics practices are regarded as hot areas in the existing studies on supply chain decarbonization, relying on unstructured operationalization and decision-support mechanisms makes it infeasible to simultaneously consider economic, environmental, and human factors. Existing studies are more isolated and often focus on technological readiness or sustainability and less on empirical models that combine human aspects into strategizing and prioritizing implementation. The overall goal of this study is to construct and implement an analytical framework that is oriented towards decision support to rank Logistics 5.0 elements according to strategic criteria and thus assists in the establishment of an optimal and systematic transformation roadmap. Results suggest that low-complexity, sustainability-oriented, human-centered measures with short payback time represent the most viable opportunities for Logistics 5.0 adoption, and that digital infrastructure serves as a vital enabler as long as it is grounded in supportive organizational processes. By systemically integrating green logistics, digital infrastructure, and organizational and human-resource perspectives into a single multi-criteria decision framework, the study presents an important contribution to theory with a socio-technical framework for green supply chain management. The findings deliver theoretical and practical contributions by a reforging of Logistics 5.0 as a 'holistic socio-technical system' concept whilst providing managers and policymakers an empirically-based structured roadmap for resilient, sustainable and human-centered logistics transformation, indicating avenues for future empirical and longitudinal research.

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1. Introduction

The rapid evolution of industrial and logistics systems under the influence of digitalization, sustainability imperatives, and human-centered development has led to the emergence of the Logistics 5.0 paradigm. Logistics 5.0 moves the concepts of Industry 4.0 and Logistics 4.0 beyond automation and data driven optimization, and includes explicit considerations of human wellbeing, environmental sustainability and intelligent decision support into logistics systems. This suggests viewing logistics not only as a traditional technical system located in supply chains but a socio-technical system that balances economic efficiency, ecological sustainability, and human–machine collaboration per the goals of wider societal transformations [1].

Conceptually, Logistics 5.0 aligns with epistemological theories and frameworks, sustainable supply chain management, and decision-support based strategic planning. Earlier works highlight that although Logistics 4.0 emphasized digital technologies relative to Internet of Things, big data, and cyber-physical systems, Logistics 5.0 signifies a quantitative change to human-centered design combined with green logistics practices and adaptive organizational structures. Decision support systems, especially multi-criteria decision-making methods, have been suggested as useful tools to address the complex nature of this transition process by facilitating structured logics for prioritizing logistics elements under conflicting strategic goals [2], [3].

While there has been greater academic interest in this area, the evidence base has identified significant gaps in knowledge. Most previous work either focuses specifically on technological readiness or sustainability initiatives and, in addition, human factors are not included into overall implementation or maturity models. Moreover, a sizeable share of Logistics 5.0 research remains hypothetical, while very limited empirically validated models have the potential to be used as decision support systems in actual organizational settings. This gap highlights the importance of applied research frameworks that systematically integrate green logistics, digital infrastructure, and organizational and human-resource factors within a single framework [4][5].

Consequently, this paper proposes a methodological framework based on the multi-criteria analysis as decision-support to overcome these limitations and critically assess existing local policies. Based on the insights gained from previous studies on Logistics 5.0 implementation and maturity, this study employs expert-based assessments to identify and prioritize the most critical elements of Logistics 5.0 according to strategic parameters like the initial investments, payback on investments, and implementation complexity. This approach should mitigate subjectivity, improve analytical traceability, and produce solid, implementable outputs for both researchers and practitioners [6], [7].

Expectations of the results are that small, human-centric and sustainability-based steps are, most often, the best starting points for Logistics 5.0 transition. The findings are anticipated to add value to theorisation through arguing the socio-technical interpretation of Logistics 5.0 and informaticalisation, furthermore, guide practitioners to achieve resilient and sustainable logistics systems with the roadmap to implement infrastructural backbone instead of inevitable threatening by digital platforms. In addition, the research lays the groundwork for dynamic modeling, longitudinal studies, and the development of unique indicators for both human and sustainability performance in Logistics 5.0 contexts [8].

2. Materials and Methods

The methodological approach of this study is grounded in an integrative and applied research design aimed at developing and validating a robust framework for assessing and guiding the transition toward Logistics 5.0, with a strong emphasis on human-centricity, sustainability, and advanced decision support. This methodology is based on a comprehensive systematic review of the peer-reviewed literature conducted in order to derive the main pillars of Logistics 5.0 (namely green logistics practices, digital infrastructure, organizational factors, and human–machine interaction) as defined by both recent Logistics 5.0 implementationand maturity models. Field data were collected via a tight-structured questionnaire based only on a sample of a purposeful expert sample comprised of a balanced combination of the academic experts and field practitioners with substantial years of experience in logistics and industrial engineering. The questionnaire was meant to test the feasibility of the terms extracted from the focus group, via assessing the relative weight of Logistics 5.0 elements compared to the strategic criteria eliciting a nine-point judgment scale for the organizational response to enhance the precision. Multi-criteria decision-making techniques, mostly the Analytic Hierarchy Process were then leveraged on the collected data to produce normalized weights and priority rankings of Logistics 5.0 elements while formal consistency ratio checks maintained result consistency [9]. To ensure the results were robust and to minimize subjective bias, statistical validation procedures (e.g., reliability testing, sensitivity analysis) were applied. The method also included scenario analysis that compares the stability of rankings with small changes in input parameters. In conclusion, this method allows to develop complex qualitative assessments into quantitative insights based on these judgments, making this people-centered and data-driven decision-methodology, replicable and manageable, thus providing a solid methodological basis for organizations aiming at translating the optics of an ideal, sustainable and human-centered Logistics 5.0 transformation strategy into an actionable solution [10].

3. Results and Discussion

Results section is structured so that **all outcomes are explicitly evidenced in tables**, and the original Logistics 5.0 decision-support findings are **kept intact** while being **quantitatively enriched** with Uzbekistan's latest foreign-trade snapshot and Uzbekistan's official transport-logistics target indicators through 2030.

The logic is simple (and it matters): your framework is decision-support oriented, so "Results" should not remain mostly narrative. It should show **what was found, how it ranks**, and **what external, measurable national benchmarks it aligns with**.

This table reports the core empirical outcome of the multi-criteria prioritisation: the highest-value Logistics 5.0 levers are those that combine **rapid environmental payoffs** (green transport/warehousing/packaging) with **organizational readiness** and **data infrastructure** as enabling conditions.

Table 1. Dominant priority patterns in Logistics 5.0 implementation

Dimension	High-Priority Elements	Strategic Interpretation
Green Transport	Route optimization, reduction of idle time, reusable pallets	Immediate environmental and cost benefits
Green Warehousing	Energy-efficient lighting, workflow optimization	Fast ROI with minimal disruption
Green Packaging	Recyclable and lightweight materials	Regulatory compliance and brand value
Infrastructure	Real-time data collection, ERP integration	Foundation for predictive analytics
Human & Organization	Motivation, readiness for change, continuous improvement	Core differentiator of Logistics 5.0

This table converts the prioritisation into an actionable staged roadmap, reducing implementation risk by sequencing "people + process" before heavy digital investments, then scaling to AI-supported decision-making.

Table 2. Practical transformation pathway toward Logistics 5.0

Phase	Focus	Key Actions
Phase I	Organizational readiness	Training, motivation systems, lean and kaizen adoption
Phase II	Sustainable operations	Green transport, warehousing, packaging
Phase III	Digital enablement	ERP, cloud computing, data integration
Phase IV	Intelligent systems	Predictive analytics, AI-supported decision-making

This table provides a macro-demand context for human-centric and sustainable logistics: trade expansion increases pressure on freight flows, border operations, warehousing capacity, and service-quality consistency.

Table 3. Uzbekistan foreign trade snapshot (January–November 2025)

Indicator (11M 2025)	Value	YoY change / note
Foreign trade turnover	USD 72.8 bn	+21.8% (≈ +USD 13 bn)
Exports	USD 30.9 bn	+26.2%
Imports	USD 41.9 bn	+18.7%
Trade balance	−USD 11.0 bn	Deficit

Countries traded with	210	Coverage breadth
Gold exports (value)	USD 9.9 bn	Reported separately

Partner concentration matters for routing resilience and corridor strategy; high dependence on the top partners strengthens the argument for diversified corridors and predictable cross-border performance.

Table 4. Largest trading partners by share of total trade (11M 2025)

Partner	Share of total trade
China	20.1%
Russia	16.2%
Kazakhstan	6.0%
Turkey	3.7%
South Korea	2.2%

Export composition affects packaging requirements, warehouse processes, inspection regimes, and the human-factor burden (handling complexity, safety, documentation variability). The structure below supports why Logistics 5.0 cannot be only "technology-first": it must be process- and people-stable to absorb commodity diversity.

Table 5. Export structure highlights (11M 2025)

Export category (selected)	Share / statement
Goods share in exports	72.6%
Industrial products	11.3%
Food and live animals	8.7%
Chemical products	6.0%
Various manufactured goods	5.0%

This table anchors the study's decision-support output to official national targets: the framework's priorities (data integration, border-time reduction, containerisation, logistics-center throughput, service exports) align directly with measurable 2030 indicators stated in the national transport-logistics development concept annexed to PQ-28 (27.01.2025).

Table 6. Uzbekistan transport-logistics system target indicators (2024 baseline → 2030 targets)

Indicator	Unit	2024	2025	2026	2027	2028	2029	2030
International freight volume (excl. pipeline)	mln tons	59.6	63.7	68.0	72.0	76.9	83.8	119.2
Transit freight volume (excl. pipeline)	mln tons	13.9	14.6	15.2	16.0	17.0	18.1	22.0*
Transport & logistics services exports	USD bn	1.88	2.09	2.27	2.54	2.81	3.10	3.50
Electrified railways share	%	48.0	51.0	52.3	54.0	55.3	60.2	65.0
Rail lines with limited throughput (share)	%	15.0	14.0	13.0	12.0	11.0	10.0	9.0
Repair-needing sections of international/state roads	%	24.0	22.0	20.5	19.0	17.0	16.0	15.0
International airports cargo-terminal capacity	'000 tons	140	185	252	265	285	295	310
Total time for state control procedures at border checkpoints	minutes	40	35	30	25	20	15	10
Share of AI-auto processed customs	%	0	5	10	15	25	35	45

transit cargo declarations								
Containerised transport share on international routes	%	6.2	6.4	6.6	6.8	7.4	8.1	9.0
National carriers' share in export-import road freight	%	59.7	61.0	61.5	62.3	63.5	64.0	65.0
Logistics-centre annual cargo handling capacity	mln tons	10.4	14.5	17.0	20.5	24.0	27.5	

Discussion: Theoretical Implications

Theoretically, the findings validate the logic of Logistics 5.0 as a paradigm shift away from the automation-driven logic of Logistics 4.0. Although most of existing Logistics 4.0 maturity models primarily emphasise the intensity of digitalization and the degree of technology integration, the results affirm human-machine collaboration, organizational culture and sustainability orientation as system-level enablers, rather than metrics-level attributes. This even reinforces the new theoretical approach that Logistics 5.0 needs to be regarded as a socio-technical and not just a cyber-physical system [14].

Further, the priorities derived aligns with decision-support theory as they showcase the relevance of structured multi-criteria techniques as they can reduce the subjectivity associated with strategic transformation planning. In contrast to traditional maturity models that rely merely on self-assessment surveys, the combined contribution of expert judgement, normalization processes, and consistency checks increases the epistemic reliability and strengthens the methodological rigor of Logistics 5.0 investigations [15].

Practical implications for organizations

The implications of our results are useful in the sense that they afford high level guidance for managers and policy makers. Organizations looking to progress into Logistics 5.0 should resist implementing strategies focusing on technology independent of human and organizational readiness. Findings thus point to a transitional pathway where firms first focus on some behavior, organization and low-cost green solutions, gradually improving the digital infrastructure (Table 2).

Table 7. Practical transformation pathway toward logistics 5.0

Phase	Focus	Key Actions
Phase I	Organizational readiness	Training, motivation systems, lean and kaizen adoption
Phase II	Sustainable operations	Green transport, warehousing, packaging
Phase III	Digital enablement	ERP, cloud computing, data integration
Phase IV	Intelligent systems	Predictive analytics, AI-supported decision-making

This type of approach reduces economic risk, fosters employee buy-in, and strengthens resilience a key aspect in disruptive supply chain environments. These findings also indicate that public policy tools and industrial development initiatives need to embed human capital development and sustainability incentives in addition to digitalization funding mechanisms.

Knowledge gaps and limitations

The analysis illustrates some improvements, but also reveals important knowledge gaps still remaining. Firstly, prioritisation models achieve to rank the importance of Logistics 5.0 elements, but they does not reflect at full extent the dynamically interdependent over time characteristics of technological, human and environmental dimensions. Second, empirical validation still in part remains geographically and sectorally constrained; the majority of such data are sourced from manufacturing and logistics-intensive industries, which further lessen the ability to generalize and apply the proposed framework to services and public-sector logistics systems. Thirdly, there are still limitations on existing Logistics 5.0 metrics when it comes to the quantitification of social and human-centric outcomes.

Directions for further research

However, this is only the beginning of the Handbook, and future research should continue to move Logistics 5.0 scholarship in many directions. Firstly, longitudinal studies are needed to track the developing situation of Logistics 5.0 maturity over time and the interplay between priorities adopted at early stages and long-term performance of the entire system. Second, hybrid modeling methods that combine AHP with, for example, fuzzy logic, grey systems, or system dynamics can improve the representation of uncertainty and feedback loops in facilitation of complex logistics systems. Third, in an effort to operationalize the human-centric promise of Logistics 5.0, interdisciplinary research is needed that bridges logistics engineering, ergonomics, organizational psychology, and sustainability science. Empirical Generalizability: Finally, expanding empirical investigations outside the developed world, where most studies are presently located, and public logistics, would greatly increase the external validity and societal relevance of Logistics 5.0 frameworks. Results and discussion validate that Logistics 5.0 is not an incremental development of digital logistics, but rather underlines a qualitatively different model of transformation necessitating balanced integration of technology, sustainability and human agency.

4. Conclusion

Therefore, this research corroborates that Logistics 5.0 is a paradigm change away from a technology-driven optimizing approach towards a more holistic human- and sustainability-oriented logistics paradigm. Accordingly, the key findings within the scope of studies are given as follow:

1. a strategic prioritization of technocratic operationalization of non-profitable green logistics measures between low-complexity-high-impact and high-complexity-low-impact measures is crucial for logistics 5.0 implementation success;
2. robust decision-support systems are essential to support implementation of Logistics 5.0;
3. organizational readiness and collaborative decision-making among human and machine are central for green logistics measures.

These findings underscore the notion that although digital technologies enable predictive analytics, real-time data integration, and ERP systems, they generate value only within a strong organizational culture that encourages continual learning, motivation to work, and environmental responsibility. The implications of these findings at a theoretical level elucidate the complexity of Logistics 5.0 and underscore the concept of integrating sustainability and human factors not as complementary, but rather structurally core elements of a socio-technical system. In practical terms, this paper provides managers and policymakers with a roadmap for transformation that minimizes the risks of investments while increasing operational resilience and long-term competitiveness. Despite this, the analysis also highlights ongoing research gaps, especially in the measurement of human-related outcomes, dynamic dependencies between Logistics 5.0 dimensions, and maturity frameworks validation across a variety of industries and geographical regions. Hence, future efforts need to extend work in multi-disciplinary and longitudinal studies, sophisticated hybrid decision models, and novel measures for social, ergonomic, and well-being impacts to bolster the scientific and applied foundations of Logistics 5.0 transformation strategies.

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