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# An Integrated AHP–DEMATEL Decision-Support Framework for Sustainable Closed-Loop Apparel Supply Chain Design and Stakeholder Alignment

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**ABSTRACT**

To establish an effective closed-loop apparel supply chain (CLASC), it is essential to achieve a workable balance across environmental, social, and economic priorities while also addressing the varied expectations of participating actors. This study proposes an integrated application of the Analytic Hierarchy Process (AHP) and the Decision-Making Trial and Evaluation Laboratory (DEMATEL) to support consensus-building during the planning and design stages of Community-Led Action for Sustainable Communities (CLASC). Within the AHP stage, specialist panels evaluate and prioritise the principal criteria from the standpoint of manufacturers, retailers, consumers, and regulatory authorities. The DEMATEL phase then clarifies how these criteria interact, particularly in terms of influence and dependence among system elements. Considering the insights jointly derived from both models enables stakeholders to recognise the underlying factors and relational pathways that shape the functioning and performance of the closed-loop structure. To verify the usefulness of the framework, empirical evidence and professional perspectives from supply chain practitioners were incorporated. The findings indicate that environmental regulation adherence, well-organised reverse logistics, effective stakeholder coordination, and consumer awareness are central considerations when establishing a CLASC. Additionally, DEMATEL exposes key causal linkages and dominance patterns that must be managed so that the priorities of various supply chain participants can be harmonised. The combined AHP–DEMATEL approach therefore strengthens decision clarity and promotes unified strategic direction. It contributes to circular economy research by offering a practical multi-criteria decision-support tool tailored for the apparel industry, and provides valuable guidance for both supply chain managers and policy developers aiming to implement sustainability-oriented, stakeholder-driven closed-loop arrangements.

## 1. Introduction

Over recent years, the apparel sector has faced intense global competition, rapid shifts in consumer expectations, and heightened concern over environmental impacts. Conventional linear

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supply models have increasingly been criticized due to their high resource demands and the substantial waste they generate [10]. As a result, the idea of CLSC has gained prominence as a more environmentally conscious resource management strategy [33]. Within CLSC systems, the processes of take-back, recovery, recycling, and component reintroduction operate with the same significance as forward product flows [31]. This is particularly relevant in apparel, where large volumes of textile discards and accelerated fashion cycles intensify sustainability challenges [5]. When properly implemented, CLSC approaches reduce ecological burdens, conserve resources, and reinforce the circular economy, although doing so requires comprehensive awareness of the actors and operational dynamics involved [22].

Embedding sustainability into apparel supply structures involves engaging with the economic, environmental, and social dimensions commonly referred to as the triple bottom line [17]. The effectiveness of any CLASC depends on maintaining equilibrium among these dimensions. However, the various parties associated with sustainability—such as producers, retailers, consumers, advocacy bodies, and governmental authorities—often hold diverging interests [9]. For instance, producers may prioritise cost efficiency and output optimisation, while regulators emphasise adherence to environmental standards and reducing emissions [26]. Retailers typically focus on profitability and customer retention, whereas consumers may place value on ethically produced and recyclable garments. Consequently, aligning these contrasting aims is both complex and necessary for successful CLASC implementation [21]. Any attempt to restructure the supply chain is likely to be inadequate if organisational leadership does not adopt a cohesive and balanced approach to these priorities.

MCDM frameworks have emerged as a means of managing decision complexity when multiple stakeholder perspectives must be accounted for [25]. AHP is frequently applied to rank factors by allowing experts to evaluate their comparative significance [8]. In contrast, DEMATEL is used to investigate the directional influence and interdependence among factors, revealing which ones act as driving forces and which function as outcomes [1; 2]. AHP clarifies the relative priority of considerations, while DEMATEL uncovers the structural relationships among them [20]. Using both approaches together supports the development of a more strategic and system-oriented evaluation that integrates stakeholder viewpoints and articulates the interactions among priorities [28].

This research proposes integrating AHP and DEMATEL to guide the formulation and planning of CLASC through structured stakeholder collaboration. Under this combined approach, decision-makers assign importance weights to sustainability elements through expert input (AHP) and then map the influence pathways among these elements (DEMATEL). The resulting framework identifies critical factors such as regulatory adherence, reverse logistics performance, stakeholder coordination, and consumer awareness as central determinants of supply chain sustainability. Moreover, DEMATEL reveals feedback mechanisms and influence patterns that either facilitate or hinder consensus-building among participants. Thus, the integrated approach strengthens communicative alignment among stakeholders and informs the development of environmentally responsible and stakeholder-oriented closed-loop models in the apparel field. The findings illustrate that employing combined decision-making methodologies enhances cooperation and contributes to the broader advancement of sustainable supply chain systems.

## 2. Related Works

Academic interest in developing sustainable and stakeholder-oriented CLASC models has increased considerably in recent years. Within this context, MCDM-based frameworks have frequently been applied to address the challenges of integrating diverse stakeholder expectations while maintaining sustainability performance throughout the supply chain. Numerous studies have been examined that employed AHP, DEMATEL, Fuzzy Logic, ISM, and various hybrid techniques. Each method demonstrates particular strengths—for instance, offering structured prioritisation of criteria or clarifying interdependencies among system elements—yet they also display limitations, including subjectivity in assessment, computational complexity, or reduced adaptability when new conditions arise. To summarise the existing body of work, Table 1 presents key findings from selected contributions. It reports the methodological combinations used, the main benefits achieved, and the constraints observed. These insights collectively form the foundation upon which the present study constructs its integrated AHP–DEMATEL framework for examining and guiding CLASC planning and stakeholder coordination.

**Table 1:**
Studies on Closed-Loop Supply Chains — Techniques, Advantages, and Limitations

| Authors | Techniques Involved | Advantages | Disadvantages |
|---|---|---|---|
| Denizel and Schumm [13] | Literature Review, Comparative Analysis | Provides an extensive overview of apparel CLSCs and highlights research gaps | Lacks empirical testing or quantitative validation |
| Donmezer et al. [15] | Closed-Loop Design, Digital Twin, E-Libraries | Encourages innovation by integrating Industry 5.0 technologies | Implementation is complex and technologically demanding |
| Amoozad Mahdiraji et al. [3] | Fuzzy Multi-Layer Decision-Making Framework | Enhances resilience under uncertainty and aids risk management | Subjective in nature and challenging to calibrate fuzzy inputs |
| Villar et al. [34] | Human-Centric Redesign, Post-Pandemic Resilience Modelling | Emphasises sustainability, resilience, and social responsibility | Conceptual framework only, lacks empirical case studies |
| Bhattacharya et al. [7] | AI Integration, Systematic Literature Review | Offers a thorough survey of AI applications in CLSCs | No practical implementation or validation provided |

Denizel and Schumm [13] conducted an extensive review and comparison of previous studies concerning CLSC within the apparel sector. Their work highlighted key knowledge gaps, recurring operational challenges, and dominant practices across the field. However, although the review is thorough, it remains conceptual, offering no empirical validation or quantitative assessment to substantiate its conclusions. Donmezer et al. [15] proposed incorporating Industry 5.0 concepts, particularly digital twin systems and digital knowledge repositories, into CLSC arrangements. Their intention was to enhance transparency and recovery rates in garment flows. Nonetheless, the adoption of such advanced systems introduces significant barriers, as these technologies are costly and require specialised expertise, making implementation difficult.

Amoozad Mahdiraji et al. [3] put forward a framework to support decarbonised CLSC operations under uncertain and disruptive conditions. Their approach demonstrates potential for handling risks during events such as the COVID-19 pandemic. Even so, the model's effectiveness is restricted by its strong dependence on subjective judgement, which may not remain stable across decision contexts. Villar et al. [34] emphasised the importance of human-centred perspectives in building resilient and responsible supply networks, particularly throughout pandemic and post-pandemic transitions. Their focus is on adaptability and social considerations within supply chain transformation. However, their contribution lacks real-world case validation to demonstrate how the proposed principles translate into practice. Bhattacharya et al. [7] examined the role of AI in enhancing CLSC performance. Their study outlines how AI may support various supply chain activities. Yet, similar to other works, the lack of implementation-based evidence limits understanding of how these technological solutions function in actual industrial settings.

Despite meaningful progress in existing literature, several issues remain unresolved. Many AI-oriented and technologically driven solutions are complex, costly, and insufficiently tested in practical environments. Some decision-making frameworks overly rely on subjective perspectives, while others do not adequately integrate sustainability pillars or stakeholder alignment. Moreover, technological innovations introduced so far have not consistently resulted in workable, real-world CLSC models. Therefore, a unified framework is required—one that systematically incorporates stakeholder engagement and supports balanced sustainability priorities while guiding closed-loop operations. The integrated approach proposed in this study enables structured decision-making by combining numerical prioritization of sustainability criteria with analytical examination of interrelationships among influencing factors, thereby providing a practical foundation for designing future CLASC structures.

## 3. Integrated Framework for Sustainable Closed-Loop Apparel Supply Chain Design

The approach centers on applying stakeholder-oriented MCDM judgement alongside causal relationship analysis in order to guide sustainable and circular system design. Initially, principal actors within the CLASC—such as producers, retailers, consumers, reverse logistics operators and environmental regulatory bodies—are identified and engaged through workshops, group discussions, and survey exercises to determine their expectations and priorities. Once these perspectives are collected, the participating stakeholders jointly establish a set of sustainability criteria and organize these into a structured hierarchy for the AHP. A schematic representation of the proposed framework is illustrated in Figure 1.

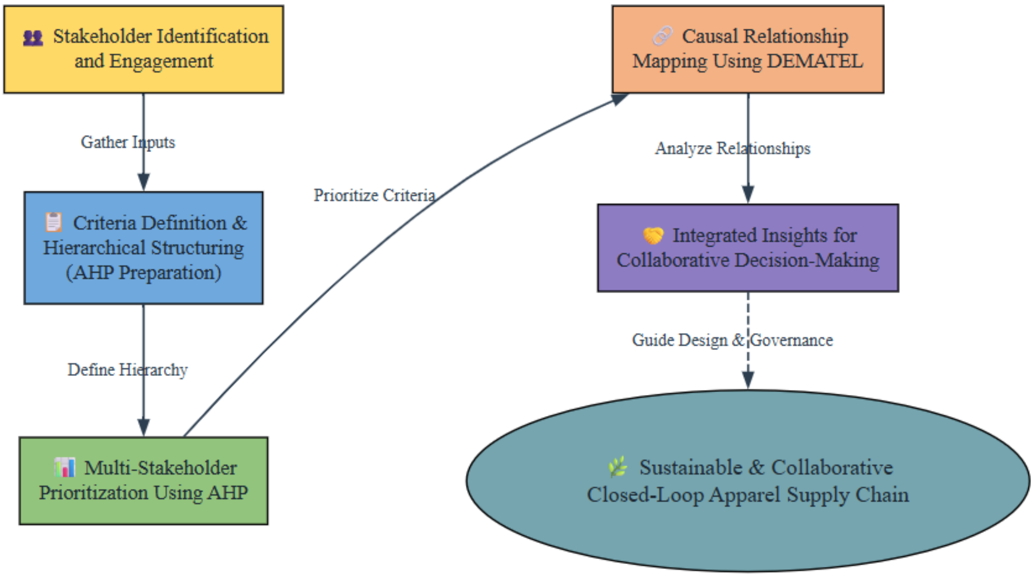


**Fig.1:** Proposed Flow Diagram

During the Multi-Stakeholder Prioritization stage, domain experts evaluate and compare the identified criteria, enabling AHP to quantify the relative significance of each factor in achieving sustainability objectives. Following this, DEMATEL is employed to uncover the direct interrelations among these criteria. Based on expert input, a total relation matrix is constructed alongside a cause–effect diagram, highlighting the key elements that drive and feedback within the supply chain. Finally, in the Integrated Insights for Collaborative Decision-Making phase, findings from both AHP and DEMATEL are synthesized to inform decisions regarding resource allocation, operational strategies, and policy formulation. Utilizing this integrated methodology ensures that CLASC is developed transparently, accommodates the interests of all stakeholders, recognizes systemic interactions, and fosters sustainability, resilience, and adherence to circular economy principles.

### *3.1 Stakeholder Identification and Engagement*

The successful implementation of a CLASC begins with the systematic identification and active engagement of all key actors within the supply chain. These include producers, retailers, consumers, reverse logistics operators, and environmental regulators. Each group plays a distinct role in determining the efficiency and sustainability of the system. Producers and retailers influence the availability and flow of goods, while consumer participation is crucial for enabling effective take-back and recycling processes. Reverse logistics operators manage the recovery and reintegration of materials, and regulators ensure compliance with environmental standards. Given the complexity and diversity of these roles, a thorough examination of the stakeholder landscape is essential to avoid overlooking critical perspectives [23]. To capture these varied interests, structured engagement activities—such as workshops, focus groups, interviews, and surveys—are conducted. These interactions are designed to elicit detailed insights into stakeholder expectations, potential challenges, and sustainability objectives related to circularity. This stage not only generates valuable information but also fosters collaboration and trust among participants [19]. The process helps identify areas requiring support, clarifies potential obstacles, and ensures equitable consideration of all voices. By integrating these inputs, the CLASC framework seeks to balance economic viability, environmental stewardship, and social responsibility, thereby promoting long-term stakeholder commitment and sustaining a resilient closed-loop operation.

### *3.2 Criteria Definition and Hierarchical Structuring (AHP Preparation)*

After the identification and engagement of stakeholders, the subsequent step involves convening all parties to determine and structure the principal criteria that will guide sustainable CLASC design. This process relies on discussions with domain experts and supply chain participants through workshops and interviews to identify the key factors influencing sustainability outcomes [6]. Commonly, these criteria encompass regulatory compliance (environmental standards), effective product take-back and recycling, collaborative practices among partners, and consumer awareness regarding eco-friendly behaviors. Each main criterion is further elaborated through sub-criteria, which capture specific dimensions of the overarching category.

Once the criteria and sub-criteria are established, they are arranged into a hierarchical framework suitable for analysis using AHP. At the apex of this hierarchy sits the primary objective: achieving a sustainable CLASC. The subsequent level contains the main criteria, with subordinate levels accommodating the corresponding sub-criteria as required. AHP then utilises pairwise comparison matrices to assess the relative weight of each criterion, based on expert judgement. The comparison of two criteria, Ci and Cj, is represented by an element a_ij in the comparison matrix A, formulated as shown in equation (1).

$$A = \left[a_{ij}\right] \;\; where\; a_{ij} = \frac{w_i}{w_j},\;\; a_{ji} = \frac{1}{a_{ij}},\;\; a_{ii} = 1 \qquad (1)$$

Here, $w_i$ and $w_j$ are the relative weights of criteria i and $j$. The normalised weights obtained from the AHP calculations indicate the relative priorities assigned by stakeholders and provide the basis for subsequent causal analysis and overall system design. This systematic methodology guarantees that each stakeholder perspective is formally considered, ensuring that the final CLASC configuration is informed by both empirical data and collective input [12].

### *3.3 Multi-Stakeholder Prioritization Using AHP*

Once the relative importance of all criteria and sub-criteria has been established, the subsequent step involves capturing stakeholder preferences through AHP [32]. At this stage, representatives from various segments of the apparel supply chain—including producers, retailers, consumers, reverse logistics operators, and environmental authorities—assess and compare the identified criteria. This process requires evaluating each pair of criteria in terms of their contribution to achieving the overarching sustainability objective within the CLASC [18]. By collecting both stakeholders' perceptions and preferences, the method ensures that diverse viewpoints are incorporated into the decision-making process. Following this, AHP synthesises the individual judgements to produce a consolidated set of weights reflecting collective priorities [4]. Essentially, in this process, you make a pairwise comparison matrix $A$ where the value$a_{ij}$ shows the importance of criterion $i$ relative to criterion $j$. From matrix $A$'s normalized principal eigenvector, we get the priority vector $W = [w_1, w_2, \ldots, w_n]$, which is explained in equation (2).

$$AW = \lambda_{max} W \qquad (2)$$

Where $\lambda_{max}$ is the largest of the values that A's eigenvectors can have. Consequently, decision-makers are provided with a structured framework that facilitates balanced consideration of all criteria, reconciles differing viewpoints, and resolves potential conflicts. This approach clarifies the factors that most influence sustainability and ensures that the final CLASC design accurately incorporates the perspectives of all stakeholders [27].

### *3.4 Causal Relationship Mapping Using DEMATEL*

After the criteria have been prioritised using AHP, it is essential to explore how they interact within the supply chain environment. To achieve this, DEMATEL is employed to examine the causal relationships among the criteria [30]. Unlike AHP, which focuses on ranking, DEMATEL identifies the interconnections between factors and the way influence is transmitted. In this stage, experts evaluate the degree to which each criterion affects others indirectly, using a scale ranging from 0 (no influence) to 4 (very strong influence) [24]. The individual assessments are compiled into a direct-relation matrix, $D$, which is subsequently normalised and transformed into a total relation matrix, $T$. This process allows calculation of each criterion's prominence and relation by summing its dispatching (outbound) and receiving (inbound) powers [11]. The results are represented in a cause–effect diagram, distinguishing key driving factors (those with strong outward influence) from dependent factors (those primarily affected by others). For instance, DEMATEL may reveal that consumer awareness supports efficient reverse logistics, or that compliance with environmental regulations strengthens stakeholder collaboration. Understanding these interdependencies enables decision-makers to manage critical linkages and feedback loops effectively, ensuring the CLASC functions cohesively [29].

### *3.5 Integrated Insights for Collaborative Decision-Making*

In the final phase, insights from both AHP and DEMATEL are integrated to inform the design, planning, and governance of the CLASC. AHP provides a ranked order of the main criteria, guiding decision-makers on how to prioritise efforts, allocate resources, and direct investments to achieve sustainability objectives [35]. Concurrently, the DEMATEL-derived causality map identifies interdependent criteria, highlights key driving factors requiring attention, and flags critical dependencies that must be monitored. This combined perspective ensures that supply chain actions are clearly aligned with systemic requirements [16]. By adopting this integrated approach, organisations make decisions grounded in transparent evidence and collective input, fostering collaboration among stakeholders. It facilitates open dialogue, clarifies operational challenges and outcomes, and supports the resolution of conflicting viewpoints [14]. Additionally, the framework ensures that CLASC designs remain adaptive and resilient by identifying opportunities for improvement. The method operationalizes circular economy principles by emphasizing continuous optimization of resource flows and inclusive stakeholder engagement, ultimately establishing a system that balances environmental responsibility with business and societal requirements.

## 4. Performance Evaluation

This section presents and interprets the results obtained from applying AHP and DEMATEL to the design and planning of a sustainable CLASC. The combined analysis addresses stakeholder priorities while examining the interrelationships among sustainability criteria. Integrating the outputs from both methods highlights the factors with the greatest influence on overall supply chain performance, stakeholder alignment, and the achievement of circular economy objectives. The findings indicate that an effective closed-loop strategy depends on compliance with environmental regulations, efficient reverse logistics, and collaborative engagement across all stakeholders, and enhanced awareness among consumers. Figure 2 presents the AHP results, highlighting the prioritised criteria for developing a CLASC. Environmental compliance emerges as the highest-ranking factor (0.35), reflecting its critical role in sustainable operations. Reverse Logistics Efficiency follows (0.25), emphasising its importance in facilitating effective product returns and recycling processes. Collaboration among stakeholders and consumer awareness receive comparable weights, underscoring the need for coordinated action and informed participation. These results align with broader sustainability principles, reinforcing the importance of environmental stewardship, advanced reverse logistics, partner cooperation, and consumer education in CLASC design. By quantifying the relative significance of each criterion, AHP provides organisations with a clear, evidence-based guide to prioritise efforts and strategically manage supply chain planning.

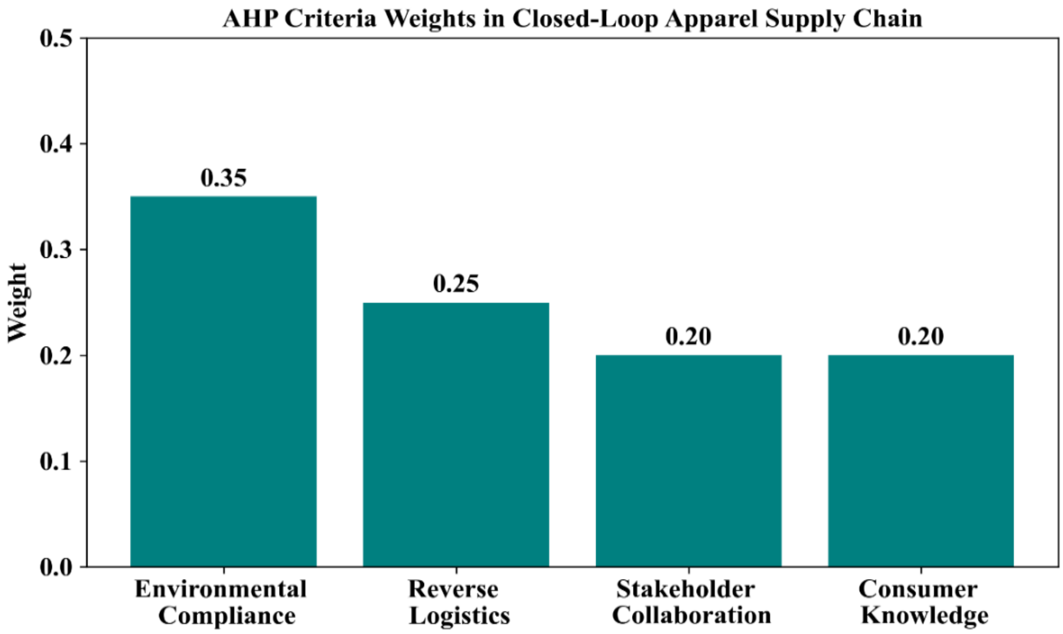


**Fig.2:** AHP Weights

The influence network illustrated in Figure 3 demonstrates the interrelationships among the principal criteria within the CLASC. Reverse Logistics exerts the strongest impact on Stakeholder Collaboration (0.50) and Environmental Compliance (0.20), highlighting its pivotal role in enhancing overall system sustainability. Consumer Knowledge also positively influences both Environmental Compliance and Stakeholder Collaboration (0.40 and 0.20), emphasizing the importance of informed consumer participation in driving system improvements. A minor value of 0.10 suggests the presence of unobserved or background factors that warrant consideration. These DEMATEL insights complement the AHP results by underlining that attention must be given not only to the priority of individual criteria but also to the interconnections among critical activities to ensure a successful CLASC.

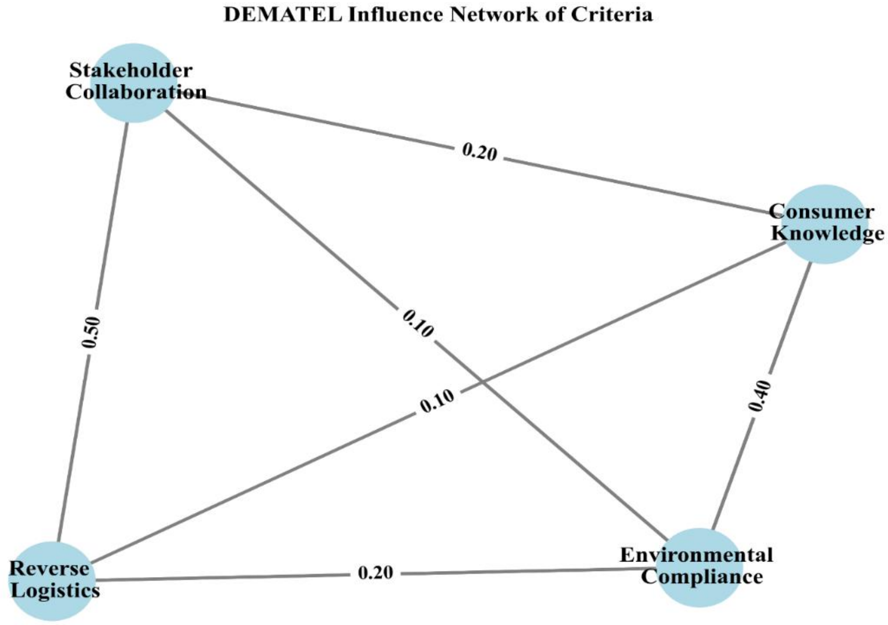


**Fig.3:** DEMATEL Influence Network of Criteria

Figure 4 presents a comparison of the proposed integrated method against Linear Weighting, TOPSIS, and Fuzzy AHP with respect to the main criteria of the CLASC. The integrated approach consistently outperforms the alternative methods, achieving the highest scores across all dimensions: Environmental Compliance (≈0.85), Reverse Logistics (≈0.90), and Stakeholder Collaboration (≈0.88). In contrast, Linear Weighting and Fuzzy AHP generally yield lower results, ranging from 0.70 to 0.75, while TOPSIS produces intermediate outcomes (approximately 0.73–0.78). These findings demonstrate that the proposed approach is particularly effective for enhancing sustainability within CLASCs. The consistently strong performance across multiple criteria indicates its suitability as a decision-support tool for implementing circular supply chain strategies.

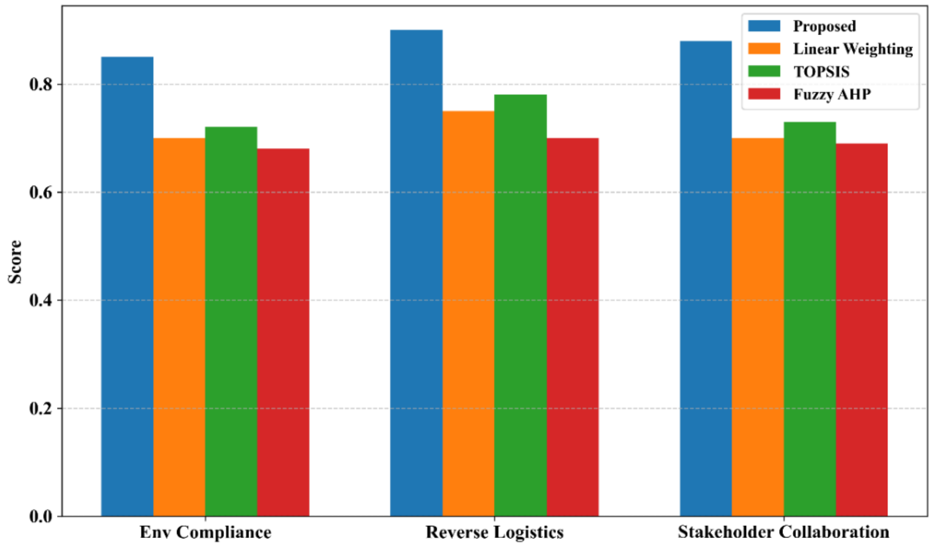


**Fig.4:** Comparative Study Validation

Figure 5 evaluates the performance of the proposed integrated method against Linear Weighting, TOPSIS, and Fuzzy AHP for key CLASC indicators: Stakeholder Satisfaction, Collaboration Level, and Knowledge Sharing. The proposed approach consistently achieves median scores above

0.85, with narrower interquartile ranges than the alternatives, indicating superior performance and lower variability. In comparison, TOPSIS, Linear Weighting, and Fuzzy AHP exhibit median values between 0.70 and 0.80, accompanied by greater dispersion and more outliers. Notably, the integrated method attains the highest scores for Stakeholder Satisfaction (~0.90) and Collaboration Level (~0.88), highlighting its effectiveness in fostering stronger stakeholder relationships within circular supply chains. These findings provide robust evidence that the proposed framework can enhance both sustainability outcomes and cooperative engagement in CLASCs.

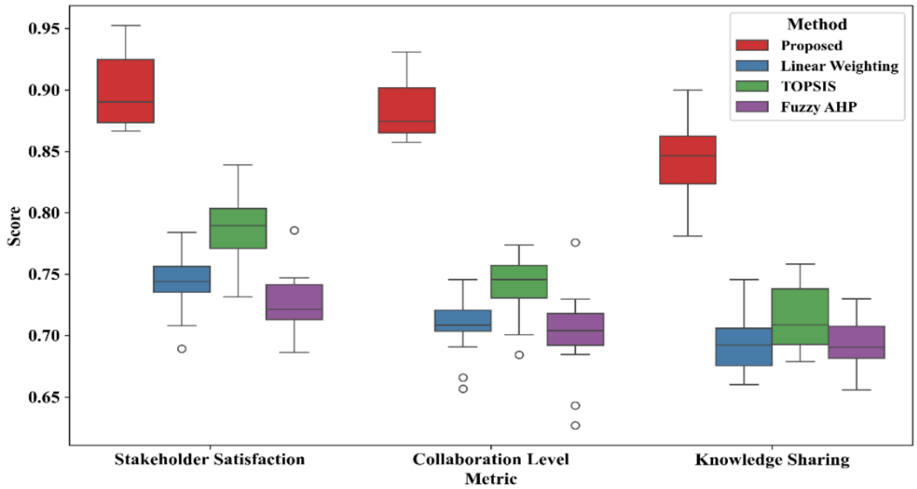


**Fig.5:** Stakeholder Impact Analysis

Figure 6 presents a comparison of the proposed integrated method with alternative techniques based on operational performance metrics: Cost Reduction (%), Lead Time Reduction (days), and Return Rate (%). The integrated approach achieves superior normalised scores across all indicators, including Cost Reduction (>0.80), Lead Time Reduction (≈0.70), and Return Rate (>0.85).

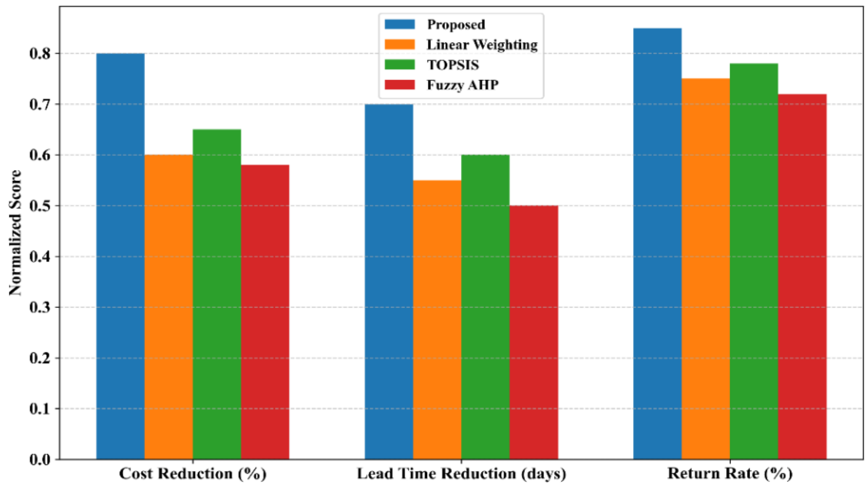


**Fig.6:** Normalized Score Validation

By contrast, the benchmark methods yield lower performance, with Fuzzy AHP recording the lowest results in every category, including a Lead Time Reduction score of 0.50. These outcomes demonstrate the method's effectiveness in enhancing the operational dimensions of CLASC. In particular, the high Return Rate highlights its capacity to increase product take-back and encourage greater customer participation in reverse logistics, thereby advancing sustainability objectives. Overall, the consistent performance across all metrics confirms that the framework supports improved efficiency, responsiveness, and operational effectiveness in closed-loop supply chain systems.

Figure 7 summarizes the comparative performance of the proposed integrated method against existing approaches across the three sustainability dimensions: Economy, Environment, and Society. The integrated framework consistently achieves the highest results, scoring above 0.88 for Economic performance, around 0.85 for Environmental performance, and exceeding 0.90 for Social performance, reflecting both stability and strong balance. In contrast, TOPSIS demonstrates moderate consistency across dimensions (0.72–0.75), while Linear Weighting and Fuzzy AHP generally exhibit declining performance, particularly in the Social dimension (approximately 0.60 for Fuzzy AHP). These outcomes indicate that the proposed framework enables CLASCs to simultaneously address economic competitiveness, environmental stewardship, and social responsibility, fulfilling contemporary sustainability requirements. The results confirm that the integrated approach effectively minimises environmental impacts while outperforming conventional MCDM methods in maintaining strong alignment with the triple bottom line.

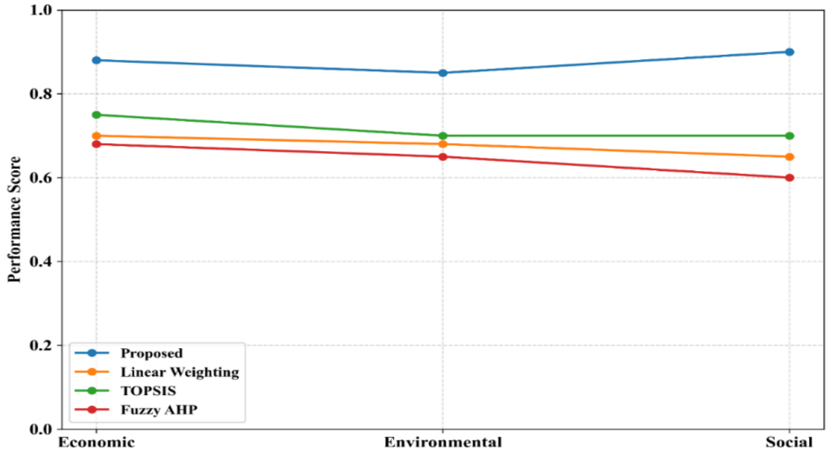


**Fig.7:** Line-Plot Sustainability

Figure 8 demonstrates that the AHP–DEMATEL integrated approach outperforms other methods in planning a CLASC within the apparel supply chain, achieving the highest average score of 0.88. This performance surpasses that of Linear Weighting, TOPSIS, and Fuzzy AHP, as the hybrid method simultaneously addresses sustainability criteria and stakeholder objectives in a more comprehensive manner. By capturing both causal relationships and stakeholder interactions, the proposed framework provides a cooperative tool for implementing sustainable, circular practices across diverse sectors.

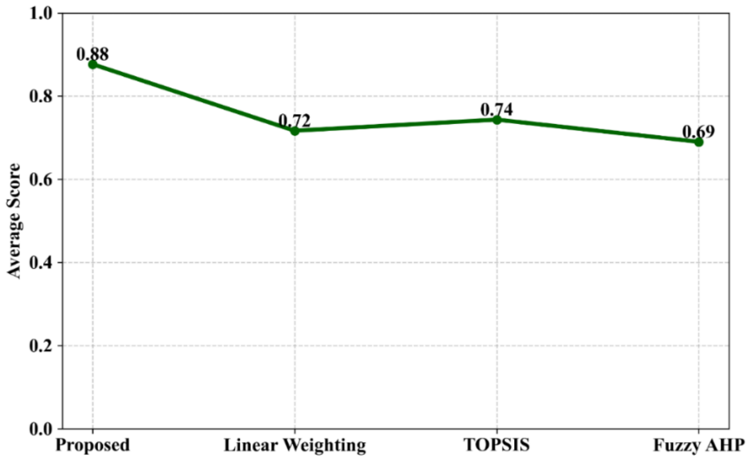


**Fig.8:** Average Score Validity

Figure 9 presents four key factors—Environmental Compliance, Reverse Logistics, Stakeholder Collaboration, and Consumer Knowledge—evaluated across four scenarios: Base, Stricter Environmental Regulations, Consumer Shift, and Logistics Disruption. Under the Base scenario, Stakeholder Collaboration achieves the highest score (0.88), followed by Environmental Compliance (0.85), Reverse Logistics (0.80), and Consumer Knowledge (0.75). In the Stricter Environmental Regulations scenario, both Environmental Compliance and Stakeholder Collaboration remain strong, while scores for Reverse Logistics and Consumer Knowledge decline slightly. Under the Consumer Shift scenario, Stakeholder Collaboration increases to 0.90 and Consumer Knowledge rises to 0.85, reflecting improved consumer engagement, whereas Reverse Logistics drops to 0.65. In the Logistics Disruption scenario, Reverse Logistics experiences the largest reduction (0.60), yet Stakeholder Collaboration (0.85) and Consumer Knowledge (0.80) maintain high levels. These results reinforce the importance of environmental compliance, efficient reverse logistics, collaborative stakeholder engagement, and informed consumers in establishing a robust and sustainable CLASC framework.

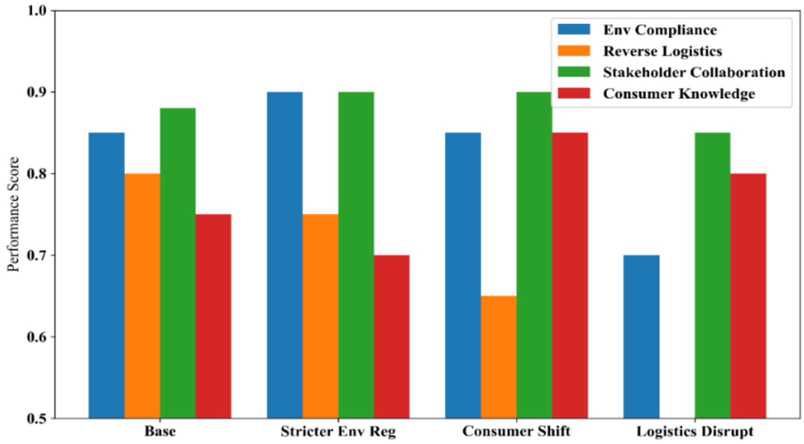


**Fig.9:** Scenario Analysis

Figure 10 illustrates the sensitivity analysis of key CLASC factors. Reverse Logistics emerges as the most influential element, with a sensitivity score of approximately 0.145, indicating that even small improvements in this area can substantially enhance overall system performance. Consumer Knowledge also plays a notable role, with a sensitivity of around 0.12, underscoring its contribution to environmental outcomes. Environmental Compliance demonstrates a sensitivity score of 0.10, reflecting its significance in maintaining sustainable operations, while Stakeholder Collaboration, though critical for strategic alignment, shows the lowest sensitivity at roughly 0.05. These findings support the conclusion that effective reverse logistics and informed consumer participation are pivotal for strengthening and advancing a sustainable, stakeholder-oriented CLASC.

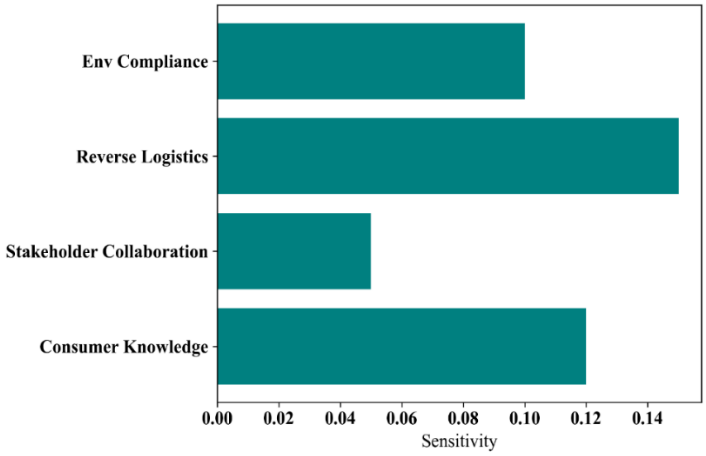

**Fig.10:** Sensitivity Analysis

## 5. Discussion

The combined application of AHP and DEMATEL indicates that Environmental Compliance holds the highest priority (0.35), followed by Reverse Logistics (0.25), while Stakeholder Collaboration and Consumer Knowledge are also critical, each with a weight of 0.20. Reverse Logistics serves as the primary driver for promoting stakeholder cooperation and adherence to environmental standards, whereas Consumer Knowledge significantly reinforces both outcomes. Implementation of the proposed integrated method yields superior performance compared to alternative approaches, with high scores in Environmental Compliance (~0.85), Reverse Logistics (~0.90), Stakeholder Collaboration (~0.88), and Consumer Knowledge (~0.85). Under various disruption scenarios, stakeholder engagement remains robust, though Reverse Logistics performance can decline (down to 0.60), highlighting the need for adaptive logistics strategies. Sensitivity analysis further confirms that system performance depends most heavily on Reverse Logistics (0.145) and Consumer Knowledge (0.12), followed by Environmental Compliance (0.10) and Stakeholder Collaboration (0.05). These findings emphasise that consistent regulatory adherence, efficient logistical processes, informed consumers, and collaborative stakeholder engagement are fundamental to achieving success in sustainable, stakeholder-oriented CLASCs.

## 6. Conclusion

In summary, the AHP–DEMATEL integrated approach demonstrates how a sustainable CLASC can simultaneously address the three pillars of sustainability. By combining AHP and DEMATEL, the framework ensures effective stakeholder collaboration while supporting informed decision-making throughout the supply chain. The study highlights that adherence to environmental regulations, efficient reverse logistics, active stakeholder cooperation, and consumer education are essential for achieving circular economy objectives. This approach enables organisations to enhance operational efficiency, strengthen resilience, and engage stakeholders collectively in environmental stewardship. The framework offers practical guidance for the apparel sector and provides a foundation for establishing new sustainable supply chain systems. Moreover, it is adaptable to emerging trends and regulatory changes, allowing organisations to maintain robust and sustainable operations over the long term. Future research may extend this methodology, applying it across different industries to further promote sustainable practices.

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