Industrial Engineering Journal
ISSN: 0970-2555
Volume : 51, Issue 7, July 2022

"Sustainable Transformation of the Chemical Supply Chain: A Strategic Approach"

* Dr. V.L.L.Narasimha Rao, Balne, Assistant Professor, Avanthi's Post Graduate & Research Academy, Hyderabad. Telangana.

**Dr. Krishna Veni Lokavarapu, Assistant Professor, Avanthi Institute of Engineering and Technology, Makavarapalem, A.P

***Mrs. D.Srilakshmi, Assistant Professor, Avanthi Institute of Engineering and Technology. Hyderabad, Telangana.

Abstract

In response to mounting environmental pressures, the chemical sector is under growing scrutiny to adopt sustainable practices throughout its supply chain. This review applies the VOSviewer tool to systematically analyze scholarly work from the past five years related to the greening of chemical supply chains. By conducting an extensive literature review and employing bibliometric mapping techniques, we chart the intellectual terrain, highlighting key publications, thematic groupings, and emerging research directions. The insights derived present a unique overview of current advancements, uncovering conceptual linkages and innovative approaches within this evolving field.

The strategic framework put forward in this study draws on insights from existing research to support the chemical industry's shift toward more sustainable practices. It highlights critical elements influencing environmental impact and presents practical measures that stakeholders can adopt to balance profitability with environmental responsibility. Beyond summarizing current knowledge, this review encourages deeper inquiry and cross-sector collaboration in the field of sustainable supply chain management. Designed to align with international sustainability objectives, the framework offers valuable direction for policymakers, industry leaders, and academic researchers, promoting unified action toward a cleaner, more resilient future for the chemical industry.

Keywords: Global sustainability goals, Resilient, Chemical sector, Supply chain, Sustainable evolution, Strategic framework

1. INTRODUCTION

Once primarily linked to environmental concerns, the chemical supply chain has become a central focus for sustainable transformation, bringing with it a new set of challenges tied to complex supply chain dynamics. Growing pressures to combat climate change, cut emissions, and protect natural ecosystems make it essential to closely examine current industrial practices. This study aims to offer meaningful insight into the approaches, obstacles, and potential pathways involved in making chemical supply chains more environmentally friendly.

By laying the groundwork for understanding the multifaceted nature of this transition, the research encourages continued exploration and collaborative efforts. The insights and

frameworks presented here are intended to enrich academic discourse while also serving as practical tools for industry professionals seeking to drive sustainability within the sector.

By closely examining current research, identifying new developments, and highlighting areas that remain underexplored, this paper seeks to advance the ongoing conversation around sustainability in the chemical industry's supply chain management.

2. RELATED WORKS

Shohan et al in a research paper introduces a structured framework to enhance Green Supply Chain Management (GSCM) implementation in Bangladesh's rapidly growing chemical industry. Through a comprehensive review and Delphi methodology, eight key drivers, including supplier pressure and willingness, were identified. The study employs Total Interpretive Structural Modelling (TISM) to analyse interrelationships, determining that supplier pressure is the most influential driver, while high cost poses a significant barrier. The research aims to guide industrial managers in prioritizing critical areas for successful GSCM implementation in the chemical industry to meet global competition standards.The findings indicate that the most significant driver was supplier pressure and willingness and the most important barrier was high cost[1].

Naseer et al rooted in the resource-based view theory, examines the link between green human resource management and green supply chain management. It tests the combined impact of these practices on the triple bottom lines (social, environmental, and economic performance) using a random sampling technique across 212 firms in diverse industries. The findings highlight the positive influence of green human resource management on the triple bottom lines, with internal green supply chain management mediating the relationship between green human resource management practices and sustainable performance, while external green supply chain management practices specifically mediate the environmental and social aspects of sustainable performance. The study concludes with practical insights for management and offers recommendations for future research[2].

Mishra et al emphasizes the adoption of green supply chain management practices in response to environmental concerns arising from increasing pollution. It highlights key green enablers such as waste disposal, reverse logistics, customer awareness, and clean technology, utilizing Analytical Hierarchy Process (AHP) to establish their hierarchical importance in manufacturing sectors, particularly noting the heightened consciousness and specific attention required in the Chemical industry for modifying manufacturing processes to achieve environmentally conscious business operations[3].

Junejo et al conducted in the context of chemical companies in Pakistan, investigates the mediating role of environmental education between internal environmental management, supplier selection, and green packaging on sustainable supply chain performance. With responses from 250 chemical companies, the findings reveal a partial mediation effect of environmental education, emphasizing the critical role of supplier selection in achieving a sustainable supply chain in developing countries like Pakistan[4].

Kumar et al explored the integration of green supply chain management (GSCM) in response to environmental challenges faced by corporate entities, particularly emphasizing the crucial

role of small and medium-sized businesses (SMEs). It delves into the transformative impact of GSCM on procurement, production, distribution, consumption, and resource recycling, and additionally reviews the rising trend of employing machine learning approaches in data analytics for operations management within the broader context of the industry[5].

Majumdar et al in a research investigated the barriers to green textile and apparel supply chain management in Southeast Asia, a region known as the production hub for lean textile and apparel supply chains. Utilizing interpretive structural modelling (ISM), the study identifies twelve crucial barriers, highlighting the complexity of green process and system design as the most fundamental obstacle. The research emphasizes the need for concerted efforts, including green technological innovation, consumer awareness, and support from regulatory bodies, to address these barriers and effectively implement green supply practices in the textile and apparel supply chains, ultimately contributing to environmental conservation[6].

Patak et al in a research underscores the significance of reverse logistics services as a crucial factor in establishing a green supply chain, with a focus on customer requirements. Through a survey of purchasing managers in 100 food companies, the study reveals the substantial role of reverse logistics services, particularly emphasizing the return of defective goods as the most crucial service. The research also highlights that the perceived importance of these services is influenced by the type of item purchased, with reverse logistics services gaining greater importance in the procurement of items inherently posing environmental hazards, presenting a key opportunity for building a green supply chain[7].

Yang et al study investigates the under-explored interrelationships between supply chain collaboration (SCC) and green innovation performance, emphasizing SCC as a crucial component of green innovation strategy. Through an interpretive structural modeling (ISM) analysis involving 17 drivers, the research, validated with a case study in the automobile industry in southwestern China, reveals that relationships between supply chain partners significantly influence green innovation performance. The study advocates viewing SCC as a core element in green innovation strategies, with identified high driving and dependence powers including environmental regulations, top management commitment, and social recognition, offering theoretical and managerial implications for enhancing the value of green innovation initiatives[8].

In today's business landscape, integrating sustainability into managerial decisions and corporate strategies is widely acknowledged. Despite this recognition, many firms face significant operational challenges, especially in extending sustainability efforts to their supplier base. This study, grounded in the practice-based view and applied to supply chain practices, focuses on the chemical process industry, identifying crucial intra- and inter-organizational practices for improving supply chain sustainability. The research, based on qualitative case studies with key informants from German chemical manufacturers, contributes to the understanding of sustainability diffusion by highlighting easily transferable and imitable practices that have the potential to drive transformative changes across entire industry sectors[9].

Addressing the complexities of designing supply networks driven by renewable chemical feedstocks, this research introduces a structured approach focused on compound class-defined supply chains. The methodology involves analyzing renewable chemical feedstock sources, alternative technology options, intermediate or end-user markets, and commercial viability. The study applies this approach to the case of terpenoid feedstocks, particularly exploring renewable feedstock supply chain options for 'green' pharmaceuticals like paracetamol, drawing evidence from literature collation, semi-structured interviews, and expert panels with industry and academic informants. The research contributes to operations management literature by proposing a systematic approach for mapping and designing renewable chemical feedstock supply chains, emphasizing source material considerations over traditional end-market applications and showcasing the utility of renewable feedstocks in extended supply chains from a circular economy perspective[10].

Addressing the significance of Green Supply Chain Management (GSCM) in organizations with substantial investments in annual personnel training, this research employs a multi-criteria assessment to evaluate the effectiveness of GSCM training. Utilizing the four top-level processes of the Supply Chain Operations Reference Model (SCOR), namely Plan, Source, Make, and Deliver, Analytic Hierarchy Process is applied to assess training impacts in the chemical industry. The study reveals that the training significantly contributes to both organizational (87%) and individual (77%) benefits, with a focus on implementing GSCM best practices, fostering a shared understanding of vocabulary and processes, and enhancing knowledge and skills in GSCM. The presented results, validated as consistent and feasible, provide valuable insights for managers in optimizing GSCM training outcomes[11]..

While sustainability's impact on innovation is well-established, this study explores the effectiveness of sustainable supply chain integration in driving green innovations. Grounded in information processing theory and dynamic capability view, the research presents a framework linking sustainable supply chain integration, green innovation, and firm performance. Using survey data from 296 manufacturing firms across 19 sectors in Pakistan, the study employs structural equation modelling, revealing that sustainable internal, supplier, and customer integration positively influence both green managerial and process innovations. The findings further highlight the positive impact of green managerial innovation on financial performance, while cautioning that rapid changes in manufacturing processes may negatively affect firm profitability, providing valuable insights for both managers and researchers in sustainable supply chain management and green innovation[12].

3. RESULTS AND DISCUSSION

Systematic Literature Review on VoS viewer on green supply chain and chemical industry of 153 papers are present in the Web of Science database of last 5 years, i.e., from 2019-2023 is analysed.

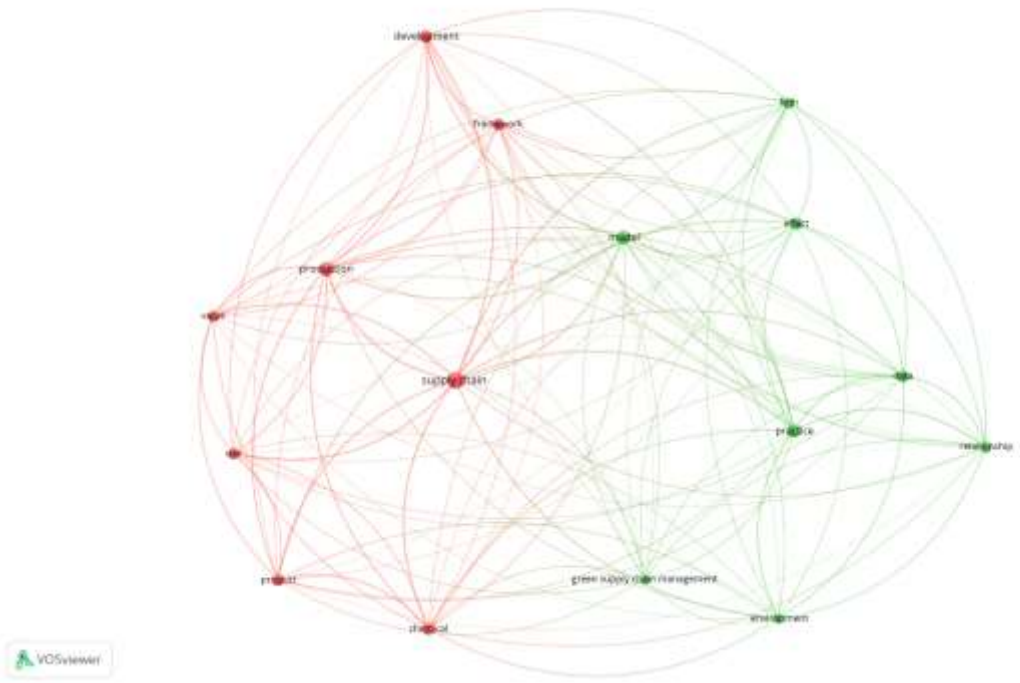

Figure1: The figure representsVOSviewer network visualization of the research field of green supply chain management

The nodes of figure 1 in the network represent different concepts in the field, and the edges represent the relationships between these concepts. The size of the nodes is proportional to the number of times they appear in the research literature, and the thickness of the edges is proportional to the strength of the relationships between the concepts.

The most prominent concepts in the network are green supply chain management, environment, chemical, development, framework, effect, supply chain, production, practice,del and relationship. These concepts are all closely connected to each other, suggesting that they are important for understanding and managing green supply chains.

Several studies have shown the potential advantages of terms in greening supply chain in chemical industry like:

i) Green supply chain management: The process of designing, implementing, and operating supply chains in a way that minimizes environmental impact and maximizes social and economic benefits.
ii) Environment: The natural world and all of its components, including the air, water, land, and living things.
iii) Chemical: A substance that has a definite composition and characteristic properties.
iv) Development: The process of creating or improving something.
v) Framework: A set of rules or principles that provide support or guidance for something.
vi) Effect: A result or consequence of an action or event.
vii) Del: A delay or postponement.

viii) Supply chain: A network of people, organizations, resources, activities, and information involved in moving a product or service from the point of origin to the point of consumption.

ix) Production: The process of creating goods or services.

x) Practice: The actual application or use of ideas, beliefs, or methods, as opposed to their theoretical or formal aspects.

xi) Relationship: The way in which two or more people or things are connected with each other.

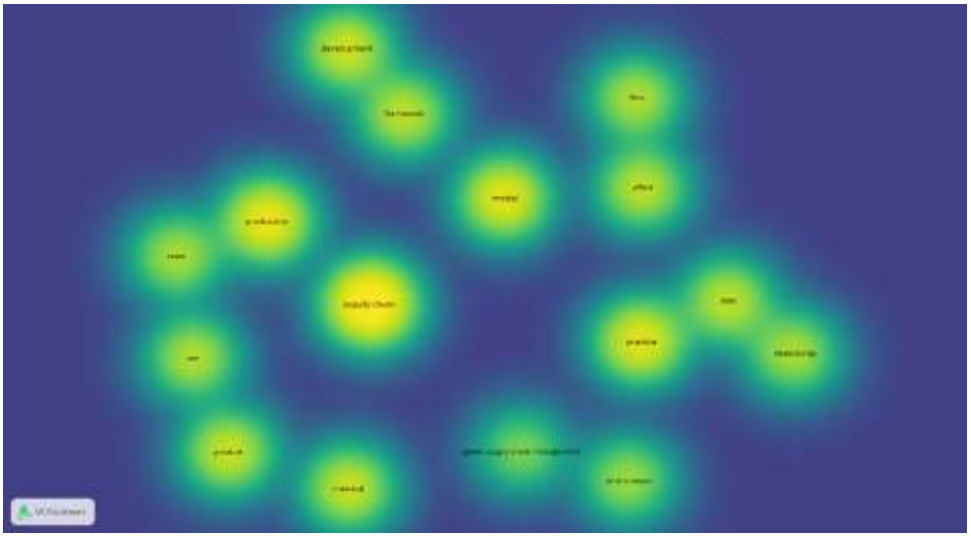

Figure2: Density Visualization of Research field in Green Supply chain management.

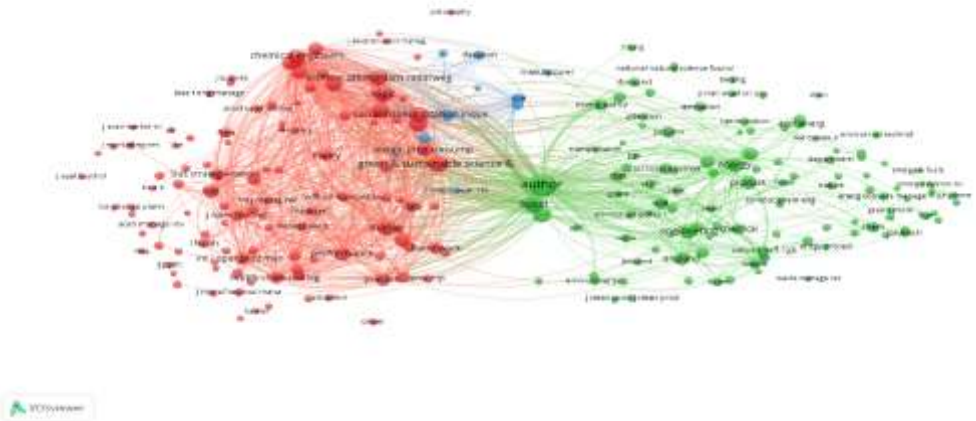

Figure 3: Network visualization of the research field of green supply chain management

The inclusion of green supply chain& sustainability in figure 2& 3 is not suprising.The nodes in the network represent different concepts in the field, and the edges represent the relationships between these concepts. The size of the nodes is proportional to the number of times they appear in the research literature,

and the thickness of the edges is proportional to the strength of the relationships between the concepts.

The most prominent concepts in the network are green supply chain management, environmental performance, green innovation, green purchasing, green supply chain integration, green supply chain management practice, impact, institutional pressure, operational performance, organizational performance, and SMEs. These concepts are all closely connected to each other, suggesting that they are important for understanding and managing green supply chains.

4. CONCLUSION

The VOS viewer network visualization between green supply chain and chemical industry provides a valuable overview of the research field of green supply chain management. It shows the key concepts in the field and the relationships between them. This information can be used to identify important research gaps and to develop new research directions.

While green supply chain practices are gaining traction in the chemical industry, their widespread adoption is still in its nascent stages. Addressing certain challenges, such as ensuring interoperability between disparate systems and navigating regulatory hurdles, is crucial for their successful implementation.

Despite these obstacles, the demand for secure and efficient green supply chain solutions in the chemical industry is projected to rise steadily in the coming years.

REFERENCES

1. Shohan, S., Ali, S. M., Kabir, G., Ahmed, S. K. K., Suhi, S. A., & Haque, T. (2019). Green supply chain management in the chemical industry: structural framework of drivers. Journal of Environmental Planning and Management, 26(8), 752-768.
2. Naseer, S., Song, H. M., Adu-Gyamfi, G., Abbass, K., & Naseer, S. (2023). Impact of green supply chain management and green human resource management practices on the sustainable performance of manufacturing firms in Pakistan. Environmental Science and Pollution Research, 30(16), 48021-48035.
3. Mishra, O. P., Chand, M., Kumar, K., & Mishra, P. (2023). Investigating applicability of green supply chain management in manufacturing sectors. International Journal of Environmental Science and Technology, 14(4), 1183-1196.
4. Junejo, I., Qureshi, F., & Khan, M. A. (2023). Mediating role of Environmental Education for Sustainable Supply chain Performance: Empirical Evidence from Chemical Companies of Pakistan. Environmental Technology & Innovation, 22(1), 131-142.
5. Kumar, V., Pallathadka, H., Sharma, S. K., Thakar, C. M., Singh, M., &Pallathadka, L. K. (2022). Role of machine learning in green supply chain management and operations management.

6. Majumdar, A., & Sinha, S. K. (2019). Analyzing the barriers of green textile supply chain management in Southeast Asia using interpretive structural modeling. Sustainable Production and Consumption, 17, 176-187.ement. Materials Today-Proceedings, 51, 2485-2489.
7. Patak, M., Branska, L., &Pecinova, Z. (2020). Importance of reverse logistics services as an antecedent for building a green supply chain. Sustainability, 33(1), 165-174.
8. Yang, Z., & Lin, Y. (2020). The effects of supply chain collaboration on green innovation performance: An interpretive structural modeling analysis. Sustainable Production and Consumption, 23, 1-10.
9. Brömer, J., Brandenburg, M., & Gold, S. (2019). Transforming Chemical Supply Chains Toward Sustainability: A Practice-Based View. Journal of Cleaner Production, 236, 117701.
10. Tsolakis, N., Barn, W., Srai, J. S., & Kumar, M. (2019). Renewable Chemical Feedstock Supply Network Design: The Case of Terpenes. Journal of Cleaner Production, 222, 802-822.
11. Tramarico, C. L., Salomon, V. A. P., &Marins, F. A. S. (2017). Multi-criteria Assessment of the Benefits of a Supply Chain Management Training Considering Green Issues. Journal of Cleaner Production, 142, 249-256
12. Junaid, M., Zhang, Q. Y., & Syed, M. W. (2022). Effects of Sustainable Supply Chain Integration on Green Innovation and Firm Performance. Sustainable Production and Consumption, 30, 145-157.