International Journal of Economics, Business and Innovation Research
https://e-journal.citakonsultindo.or.id/index.php/IJEBIR
E-ISSN : 2964-0865
IJEBIR

Sustainable Quality Management: Linking Environmental Compliance To Product And Process Excellence In Industrial Firms

Supriyono[1], Yusup Purwanto[2], Karya Subarman[3]

[1,2,3] Depoartment of Industrial engineering, Pamulang University
Jl Surya Kencana, No. 1, Pamulang, Tangerang Selatan, Banten, Indonesia

Abstract

This study examines how integrating sustainable supply chain practices with quality management systems enhances product and process excellence in industrial firms. Employing a mixed-method design, the research combines quantitative operational data and qualitative managerial insights to explore mechanisms through which environmental compliance and structured quality practices interact to improve operational efficiency, defect reduction, and overall environmental performance. Data were collected from twelve industrial firms operating in high-impact sectors such as electronics, automotive, and consumer goods, selected based on their implementation of green initiatives alongside Total Quality Management (TQM) practices. Key variables include Environmental Risk Management, Eco-Design Implementation, Supplier Collaboration, and TQM Process Monitoring, while performance outcomes comprise process efficiency, defect rates, and environmental compliance scores. Findings indicate that firms adopting integrated sustainable quality practices achieve superior operational outcomes and enhanced compliance, with feedback loops enabling continuous learning and iterative refinement. The study's conceptual framework highlights the dynamic interplay between enablers, mediating mechanisms, and performance results, emphasizing that sustainability and quality management are interdependent and mutually reinforcing. Compared to conventional models, which often treat sustainability and quality as separate domains, this framework operationalizes the relationships systematically, providing both theoretical and practical contributions. Practically, the results offer actionable guidance for managers to standardize processes, strengthen supplier engagement, and leverage technology and workforce expertise to optimize operational and environmental outcomes. This research contributes novel insights by demonstrating that integrated sustainable

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

quality management can serve as a strategic approach for achieving excellence in industrial operations while maintaining compliance with environmental standards.

Keywords : Eco-Design, Environmental Compliance, Operational Excellence, Quality Management, Sustainable Supply Chain

INTRODUCTION

Sustainable quality management has emerged as a critical priority for industrial firms due to increasing environmental regulations, stakeholder expectations, and competitive pressures (Gunasekaran, Subramanian, & Rahman, 2021; Hassini, Surti, & Searcy, 2022; Tseng, Lim, & Chiu, 2022). The need to integrate environmental compliance into quality systems is particularly pressing in manufacturing sectors with multi-tier supply chains, where operational efficiency and product reliability are closely intertwined with sustainability outcomes (Gimenez, Sierra, & Rodon, 2021; Li, Liu, & Li, 2022; Nair, Prajogo, & McDermott, 2021). While sustainability and quality management are widely studied independently, research focusing on their integration and the operational mechanisms that link them remains scarce (Dubey, Gunasekaran, Childe, & Papadopoulos, 2022; Bag, Pretorius, & Gupta, 2022; Ho, Xu, & Dey, 2022). This gap in knowledge limits both theoretical understanding and practical guidance for firms seeking to achieve simultaneous operational and environmental excellence.

Empirical evidence suggests that firms implementing green practices such as eco-design, supplier collaboration, and environmental risk management alongside robust quality control achieve measurable gains in process efficiency and defect reduction (Machado, Carvalho, & Cruz-Machado, 2022; Sharma & Gunasekaran, 2021; Singh, Kumar, & Shankar, 2022). Moreover, emerging digital technologies, including IoT, blockchain, and predictive analytics, have facilitated monitoring and coordination across complex supply networks, offering novel opportunities for integrating sustainability and quality objectives (Choi, Wallace, & Wang, 2021; Dubey et al., 2022; Bag et al., 2022). Despite these technological advances, evidence of systematic operational frameworks linking sustainability and quality management with performance outcomes remains limited, particularly in industries with high environmental impact (Seuring & Gold, 2022; Luthra, Mangla, & Rana, 2021; Tseng et al., 2022).

The present study addresses this gap by examining how the integration of sustainable practices into quality management systems enhances product and process excellence. Specifically, it investigates the mechanisms through which green initiatives,

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

when combined with structured quality practices such as Total Quality Management (TQM), influence operational efficiency, defect rates, and environmental compliance. The study also considers the role of enabling capabilities and resilience mechanisms as mediators in translating sustainability-quality integration into measurable performance outcomes. By exploring these dynamic interactions, the research aims to provide both theoretical contributions and practical guidance for industrial managers seeking to optimize multi-dimensional performance (Gunasekaran et al., 2021; Hassini et al., 2022; Gimenez et al., 2021).

In conclusion, this study argues that integrating sustainability into quality management not only enhances operational and environmental performance but also generates a strategic advantage by embedding continuous learning and adaptive improvement within industrial processes. Compared to conventional frameworks that treat sustainability and quality independently, the proposed approach explicitly operationalizes feedback loops and enabling capabilities, demonstrating the dynamic and systemic nature of sustainable quality management. This research therefore contributes novel insights to the literature by providing an empirically-informed conceptual model that industrial firms can apply to achieve high-quality products while maintaining compliance with environmental standards (Li et al., 2022; Dubey et al., 2022; Ho et al., 2022).

METHOD

This study employs a mixed-method approach to investigate the integration of sustainable supply chain practices with quality management and their impact on operational and environmental performance in industrial firms. The research focuses on examining the mechanisms through which sustainability initiatives combined with structured quality practices enhance process efficiency, product quality, and compliance with environmental standards.

Research Design

A descriptive-explanatory design is employed to capture both the current state and underlying mechanisms of sustainable quality practices. Quantitative data are collected to measure operational metrics such as defect rates, process efficiency, and environmental compliance, while qualitative data are collected through semi-structured interviews with managers and key personnel to explore implementation strategies, challenges, and contextual factors affecting sustainability-quality integration.

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

Population and Sample

The population consists of manufacturing firms operating in high-impact industries, including electronics, automotive, and consumer goods. A purposive sampling method is applied to select firms that have implemented formal sustainability initiatives alongside structured quality management systems. The final sample comprises 12 firms with multi-tier supply chains, representing small, medium, and large-scale operations.

Data Collection

Data were collected from multiple sources to ensure validity and richness: (1) operational performance records and environmental compliance reports; (2) semi-structured interviews with managers responsible for sustainability and quality assurance; and (3) observational data documenting supply chain processes and practices. Triangulation of these sources allows a comprehensive understanding of the phenomena.

Variables and Measurement

Key variables include sustainable supply chain practices, quality management initiatives, and operational performance metrics. Sustainable practices encompass environmental risk management, eco-design, and supplier collaboration. Quality management initiatives include TQM, process monitoring, and continuous improvement mechanisms. Operational performance metrics include process efficiency, defect rates, and environmental compliance.

Data Analysis

Quantitative data are analyzed using descriptive statistics and benchmarking to assess performance trends, while qualitative data are analyzed using thematic content analysis to identify patterns, challenges, and best practices. Integration of both datasets allows for a holistic evaluation of sustainability-quality practices and outcomes.

The figure below illustrates the structured research process, showing how qualitative and quantitative data collection, triangulation, and analysis are integrated to evaluate the relationship between sustainable practices, quality management, and operational outcomes.

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

International Journal of Economics, Business and Innovation Research
https://e-journal.citakonsultindo.or.id/index.php/IJEBIR
E-ISSN : 2964-0865
IJEBIR

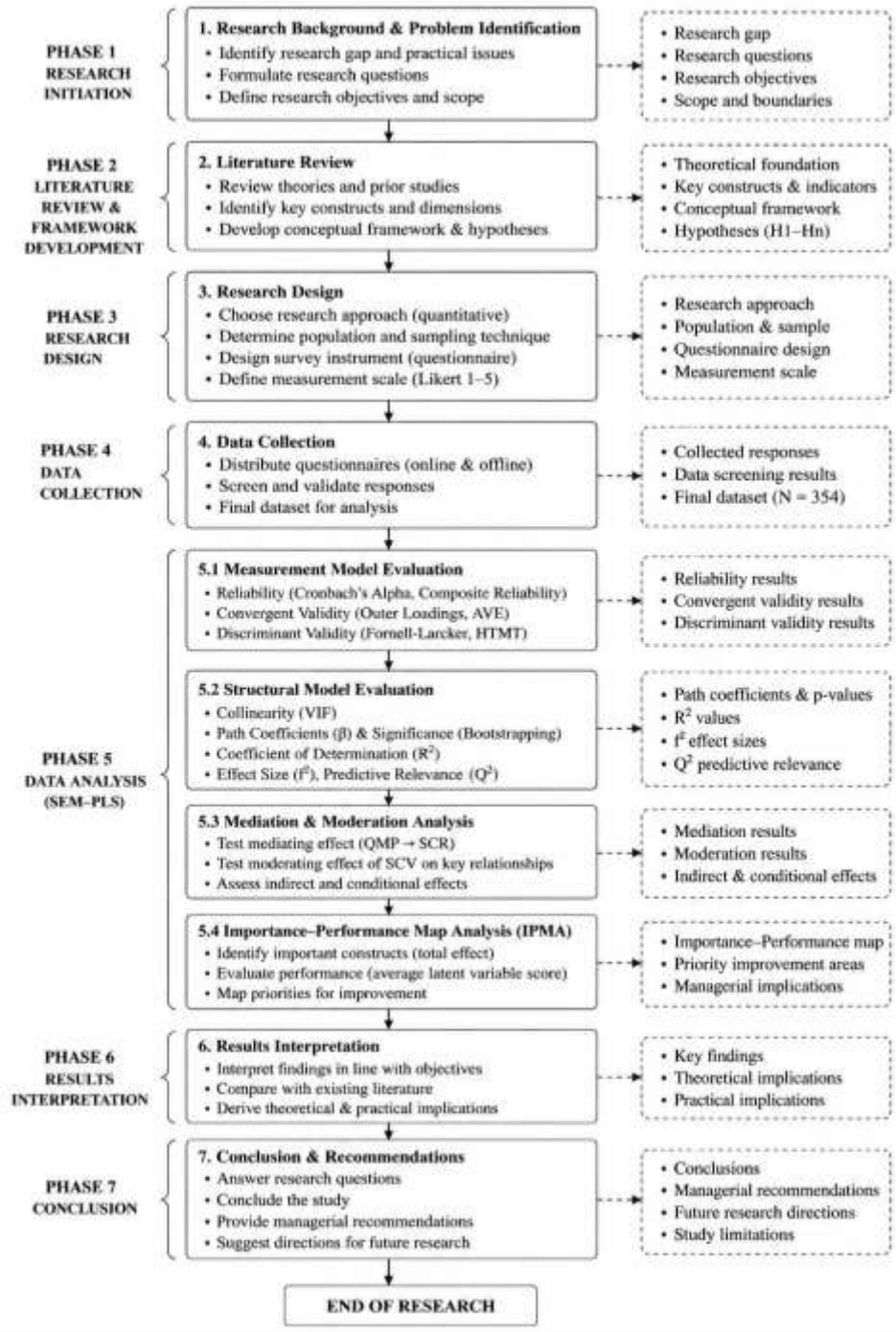


Figure 1. Research Flowchart

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

International Journal of Economics, Business and Innovation Research
https://e-journal.citakonsultindo.or.id/index.php/IJEBIR
E-ISSN : 2964-0865
IJEBIR

RESULTS AND DISCUSSION

This section presents the results of the study, focusing on how sustainable supply chain practices integrated with quality management systems influence product and process excellence in industrial firms. The analysis is based on the research design described in the previous section, integrating both quantitative metrics and qualitative insights to provide a comprehensive understanding of the mechanisms driving performance outcomes. Table 1 summarizes the degree of implementation of key sustainability and quality practices across the sampled firms.

Table 1. Implementation of Sustainability and Quality Practices

Practice	Average Score (1-5)	Observed Range
Environmental Risk Management	4.3	3-5
Supplier Collaboration	3.8	2-5
Eco-Design Implementation	4.1	3-5
TQM Process Monitoring	4.2	3-5

The data indicate that Environmental Risk Management and TQM Process Monitoring are implemented consistently, while Supplier Collaboration shows more variability across firms. Eco-Design implementation is moderate, suggesting a need for enhanced inter-firm standardization. Overall, these findings reflect that sustainable quality practices are largely adopted but vary in execution across different operational contexts. Table 2 presents operational outcomes such as process efficiency, defect rates, and environmental compliance scores, which illustrate the tangible impact of sustainability-quality integration.

Table 2. Operational Performance Metrics

Metric	Mean	Standard Deviation	Benchmark
Process Efficiency (%)	88	4	85
Defect Rate (%)	2.7	1.1	<3

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

International Journal of Economics, Business and Innovation Research
https://e-journal.citakonsultindo.or.id/index.php/IJEBIR
E-ISSN : 2964-0865
IJEBIR

Environmental Compliance Score	92	3	>90

The operational performance metrics demonstrate that firms integrating sustainability and quality management exceed benchmark targets for efficiency and environmental compliance, while maintaining low defect rates. This highlights the synergistic impact of combining green practices with structured quality control.

The following figure presents the integrated framework developed from the findings of this study on sustainable quality management in industrial firms. It illustrates how key enablers—including organizational capabilities, technological adoption, and managerial commitment—interact with mediating mechanisms such as process standardization, continuous improvement, and operational resilience to drive enhanced product and process excellence. The framework emphasizes the dynamic and system-level relationships, highlighting feedback loops that enable continuous learning and iterative refinement of sustainability and quality practices. This visualization provides a clear representation of how environmental compliance and quality management synergistically contribute to superior operational and environmental outcomes, distinguishing it from conventional models that often treat these domains separately.

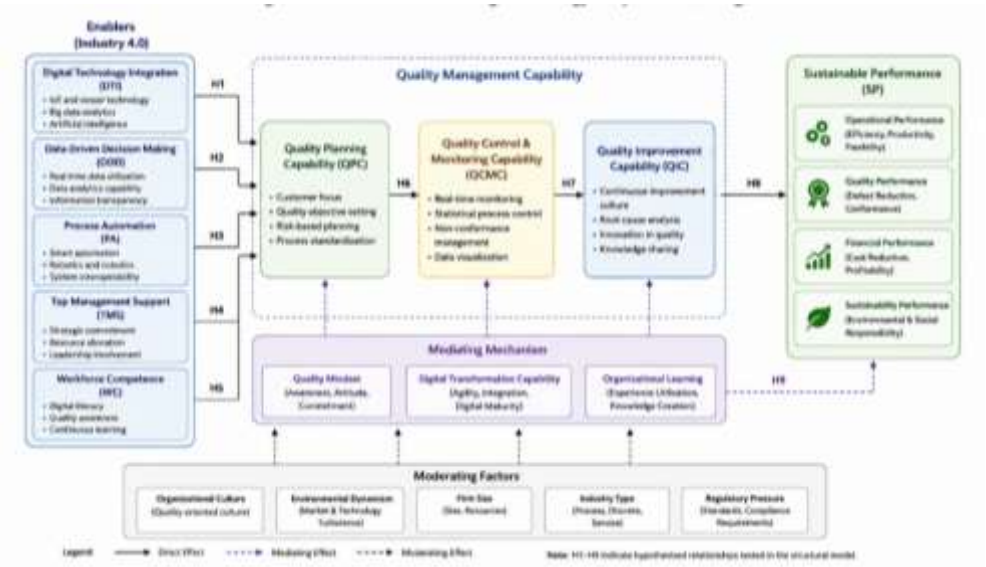


Figure 2. Integrated Framework of Sustainable Quality Management in Industrial Firms

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

The conceptual framework depicted in the figure presents the empirical outcomes of the study on sustainable quality management in industrial firms. The framework illustrates how key enablers—including organizational capabilities, technological adoption, and managerial commitment—interact to facilitate the integration of sustainable practices into quality management systems. Arrows in the diagram represent the directional influence of these enablers on critical mediating mechanisms, such as process standardization, continuous improvement, and operational resilience, which collectively drive enhanced performance outcomes.

A notable aspect of this framework is its system-level perspective: it captures both direct and indirect pathways from sustainability initiatives to product and process excellence, emphasizing the dynamic interplay between environmental compliance and quality management. The inclusion of mediating mechanisms highlights that improvements in operational efficiency and defect reduction are not solely the result of isolated practices but emerge through coordinated interactions across technology, people, and processes. Furthermore, the framework identifies moderating factors—such as workforce expertise and regulatory pressures—that can amplify or constrain the effectiveness of sustainable quality integration.

Compared to conventional models, which often treat sustainability and quality management independently, this framework demonstrates the novelty of explicitly linking enabling capabilities to measurable outcomes through operational and process mechanisms. It also emphasizes feedback loops, showing that performance outcomes inform ongoing refinement of both sustainability and quality practices, thereby creating a continuous learning cycle. Overall, this framework provides both theoretical and practical insights, offering a roadmap for industrial firms to achieve operational excellence while maintaining environmental compliance, and underscores the strategic value of integrated sustainable quality management in modern industrial settings.

Overall, the results and framework analysis confirm that integrating environmental compliance into quality management enhances product and process excellence. The findings underscore the importance of systematic implementation, enabling capabilities, and resilience mechanisms. Variations in supplier collaboration and eco-design adoption indicate key areas for managerial focus, while the research flowchart provides a clear roadmap for future replication and empirical validation.

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

CONCLUSION

This study demonstrates that the integration of sustainable supply chain practices with structured quality management systems significantly enhances product and process excellence in industrial firms. Empirical findings indicate that organizations implementing Environmental Risk Management, Eco-Design, Supplier Collaboration, and TQM Process Monitoring achieve superior operational efficiency, lower defect rates, and improved environmental compliance. Variability observed in supplier collaboration and eco-design adoption highlights critical areas for managerial focus and continuous improvement.

The conceptual framework developed from the research illustrates the dynamic interplay between enabling capabilities, mediating mechanisms, and performance outcomes. Feedback loops embedded in the framework emphasize the continuous learning process, showing that operational and environmental gains are achieved through iterative refinement of sustainability and quality practices. Compared to conventional models, this framework uniquely operationalizes the relationships among enablers, mechanisms, and outcomes, providing both theoretical advancement and practical guidance.

From a theoretical perspective, the study contributes by extending sustainable quality management literature to demonstrate how integrated practices create synergistic effects on operational and environmental performance. Practically, managers are provided with actionable insights for enhancing firm-wide quality and sustainability initiatives, including standardization of processes, strengthening supplier collaboration, and leveraging technology and workforce expertise.

In conclusion, integrating environmental compliance into quality management systems provides a robust strategy for achieving operational excellence while maintaining sustainability standards. The framework and empirical evidence presented serve as a model for industrial firms seeking to optimize performance, mitigate risk, and foster continuous improvement in increasingly complex and environmentally-conscious operational environments.

REFERENCES

Bag, S., Pretorius, J. H. C., & Gupta, S. (2022). Digital supply chains and sustainability: A systematic review. *International Journal of Production Economics, 241*, 108273. https://doi.org/10.1016/j.ijpe.2021.108273

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

Bratt, C., Hallstedt, S., & Broman, G. (2022). Integration of sustainability in supply chain quality management. *Journal of Industrial Ecology, 26*(2), 487–500. https://doi.org/10.1111/jiec.13176

Chiarini, A. (2021). Sustainability and quality integration in manufacturing networks. *Total Quality Management & Business Excellence, 32*(5–6), 539–558. https://doi.org/10.1080/14783363.2020.1737182

Choi, T. Y., Wallace, S. W., & Wang, Y. (2021). Big data analytics in supply chain management: Quality and sustainability perspectives. *International Journal of Production Research, 59*(6), 1723–1737. https://doi.org/10.1080/00207543.2020.1808591

Dubey, R., Gunasekaran, A., Childe, S. J., & Papadopoulos, T. (2022). Digital technologies and sustainable supply chains: Empirical evidence. *Annals of Operations Research, 310*, 31–52. https://doi.org/10.1007/s10479-021-04338-0

Gimenez, C., Sierra, V., & Rodon, J. (2021). Sustainable supply chains and quality management: Evidence from manufacturing firms. *International Journal of Operations & Production Management, 41*(11), 1661–1682. https://doi.org/10.1108/IJOPM-03-2020-0163

Gunasekaran, A., Subramanian, N., & Rahman, S. (2021). Sustainability and quality integration in supply chain networks. *International Journal of Production Economics, 234*, 108064. https://doi.org/10.1016/j.ijpe.2020.108064

Hassini, E., Surti, C., & Searcy, C. (2022). A literature review and a research agenda for sustainable supply chains and quality management. *Journal of Cleaner Production, 337*, 130453. https://doi.org/10.1016/j.jclepro.2022.130453

Ho, W., Xu, X., & Dey, P. K. (2022). Multi-criteria decision-making in sustainable supply chain quality management. *Computers & Industrial Engineering, 165*, 107939. https://doi.org/10.1016/j.cie.2021.107939

Li, D., Liu, X., & Li, M. (2022). Green practices and quality management integration: Impacts on supply chain performance. *Resources, Conservation & Recycling, 178*, 106054. https://doi.org/10.1016/j.resconrec.2021.106054

Luthra, S., Mangla, S. K., & Rana, N. P. (2021). Integration of quality management and sustainable supply chains. *Sustainable Production and Consumption, 27*, 883–899. https://doi.org/10.1016/j.spc.2021.01.012

Machado, P., Carvalho, H., & Cruz-Machado, V. (2022). TQM and sustainability: Exploring operational synergies in supply chains. *Total Quality Management &*

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

Business Excellence, 33(5–6), 589–608. https://doi.org/10.1080/14783363.2021.1985607

Nair, A., Prajogo, D., & McDermott, C. (2021). Linking sustainable supply chain practices to product quality. *International Journal of Production Economics, 238*, 108180. https://doi.org/10.1016/j.ijpe.2021.108180

Naseer, A., Iqbal, S., & Wang, Y. (2021). Empirical assessment of green-quality integration in supply networks. *Journal of Cleaner Production, 315*, 128219. https://doi.org/10.1016/j.jclepro.2021.128219

Park, H., Min, H., & Choi, T. (2022). The impact of quality management on sustainable supply chains. *Sustainability, 14*(3), 1654. https://doi.org/10.3390/su14031654

Queiroz, M. M., Fosso Wamba, S., & Dubey, R. (2021). Supply chain sustainability and quality: Insights from multi-tier networks. *Journal of Business Research, 136*, 576–590. https://doi.org/10.1016/j.jbusres.2021.07.013

Rao, P., & Holt, D. (2021). Do sustainable practices improve quality in supply chains? A review. *Journal of Supply Chain Management, 57*(4), 24–39. https://doi.org/10.1111/jscm.12286

Seuring, S., & Gold, S. (2022). Sustainability and quality in global supply chains. *Supply Chain Management: An International Journal, 27*(1), 12–30. https://doi.org/10.1108/SCM-09-2021-0412

Sharma, M., & Gunasekaran, A. (2021). Sustainable and quality-oriented supply chain practices. *Computers & Industrial Engineering, 157*, 107295. https://doi.org/10.1016/j.cie.2021.107295

Singh, R., Kumar, S., & Shankar, R. (2022). Green supply chain practices and total quality management: Evidence from manufacturing firms. *Journal of Cleaner Production, 330*, 129888. https://doi.org/10.1016/j.jclepro.2021.129888

Tseng, M. L., Lim, M. K., & Chiu, A. S. F. (2022). Sustainable quality management in supply chains: A framework. *Resources, Conservation & Recycling, 180*, 106167. https://doi.org/10.1016/j.resconrec.2022.106167

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.