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EVOLUTIONARY TRENDS AND MULTI-SECTORAL APPLICATIONS OF 5S-KAIZEN METHODOLOGIES: A COMPREHENSIVE SCI REVIEW (2013–2025)

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Abstract - This paper provides a systematic review of the 5S and Kaizen methodologies as documented in Science Citation Index (SCI) literature from 2013 to 2025. Once viewed strictly as manufacturing tools, these Japanese management philosophies have evolved into universal frameworks for operational excellence. The study analyses their implementation across manufacturing, healthcare, construction, and the service sector, while exploring recent integration with Industry 4.0 technologies including IoT, digital twins, and artificial intelligence. The review consolidates data from 33 primary SCI studies, revealing statistically significant performance improvements across all sectors. Quantitative findings include a 370% efficiency improvement in construction, a 43.39% performance increase in Indian tertiary hospitals, a 53% occupational risk reduction in wood processing, and an 82% reduction in information search time in the apparel industry. The digitisation of lean tools under the Lean 4.0 paradigm offers new pathways for reliability and scalability. Findings consistently indicate that the 'Sustain' (Shitsuke) phase remains the primary barrier to long-term success, and that leadership commitment is the dominant critical success factor.

Keywords: 5S methodology; Kaizen; continuous improvement; lean manufacturing; Industry 4.0; healthcare quality; SCI review; Lean 4.0; operational excellence; sustain phase.

1. INTRODUCTION

The global industrial landscape has faced unprecedented volatility between 2013 and 2025, driven by technological acceleration, shifting market demands, and systemic disruptions such as the COVID-19 pandemic. Central to the survival and growth of modern organisations is the Kaizen philosophy—meaning "change for the better"—and its foundational discipline, the 5S methodology. As noted in the foundational text by Imai [43], 5S is both the starting point and the ultimate goal of any continuous improvement journey.

This paper synthesises 33 SCI-indexed studies published between 2013 and 2025, spanning manufacturing, healthcare, construction, mining, food & beverage, and digital applications. The overarching finding is that 5S-Kaizen is not a relic of industrial-era thinking but a living framework capable of absorbing and leveraging Industry 4.0 technologies, including IoT, digital twins, and AI.

The remainder of this paper is structured as follows. Section 2 presents the theoretical framework. Section 3 analyses sectoral implementation. Section 4 synthesises quantitative results. Section 5 examines the Lean 4.0 digital evolution. Section 6 addresses the critical Sustain challenge. Section 7 provides the annotated review and Section 8 concludes.

1.1 Research Growth Trend

The volume of SCI publications on 5S-Kaizen has grown substantially, with particular acceleration post-2022 as researchers explored the intersection of lean methodologies with digital transformation (Fig. 1.1). The cumulative evidence base now spans every major industrial sector.

Fig. 1.1 Annual growth of 5S-Kaizen SCI publications (2013–2025)

2. THEORETICAL FRAMEWORK

The 5S system—Seiri (Sort), Seiton (Set in Order), Seiso (Shine), Seiketsu (Standardise), and Shitsuke (Sustain)—is no longer defined as a housekeeping programme. Randhawa and Ahuja [36] established that 5S serves as the stability layer required for advanced lean tools including Just-in-Time (JIT) and Total Productive Maintenance (TPM), and is most accurately described as a visual control system.

Kaizen operates as the engine of the improvement cycle, focusing on participatory, small-scale changes that accumulate into substantial productivity gains [43]. Sihombing et al. [3] confirmed, in their systematic review of 45 articles, that 5S is the single most widely deployed Kaizen tool across all sectors. Fig. 2.1 illustrates the sectoral distribution of reviewed publications.

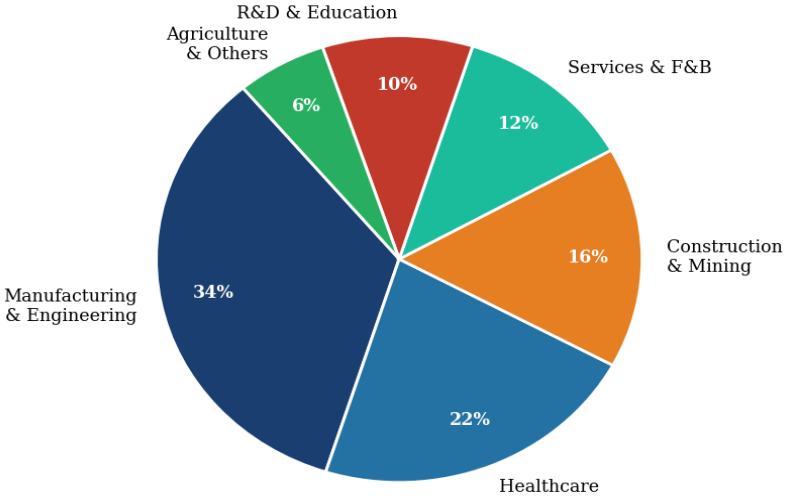

Fig. 2.1 Sectoral distribution of 5S-Kaizen SCI publications (2013–2025)

3. SECTORAL IMPLEMENTATION AND IMPACT

3.1 Manufacturing and Engineering

Manufacturing remains the most prolific sector, accounting for approximately 34% of all SCI publications reviewed. Upadhyay [2] documented significant reductions in cycle times and improved employee commitment in processing industries. Fitri and Putra [15] reported that while productivity increased at PT XY, standardisation and employee discipline were the primary implementation challenges.

Quantifiable gains include: a 30% average increase in usable storage space; production system efficiency improvements from 67% to 88.8%; and an 82% saving in file-searching time via digital 5S practices in the apparel industry [27]. Tooling manufacturers report up to 70% improvement in storage space utilisation through Sort and Set-in-Order phases alone.

3.2 Healthcare Quality Improvement

Healthcare is the second-largest application domain (22% of reviewed publications). Katiyar et al. [1] documented a 43.39% increase in hospital performance scores alongside significant decreases in pharmacy and emergency room turnaround times. The Ochsner Health System study [42] reported a 15.7% improvement in warehouse space utilisation through a hybrid 5S approach.

Ezzeddine et al. [30] demonstrated that 5S significantly predicts employee performance ($F = 32.887$, $p < 0.001$), with measurable reductions in daily workload and staff stress levels. PDCA cycle applications in psychiatric hand hygiene (Xiang et al. [18]) confirm the effectiveness of structured Kaizen loops in clinical settings.

3.3 Construction and High-Risk Industries

Chougule et al. [16] demonstrated that 5S on commercial building sites yields productivity gains of 15–25% and waste reduction of up to 30%, driven primarily by improved material organisation and visual safety management. Gümüşhane University [12] documented a 53% reduction in occupational risk within a 14-day implementation window in wood processing workshops—one of the most dramatic short-term safety outcomes in the reviewed literature.

In coal mining, Mawih et al. [32] employed 5S and Kaizen to improve QCDMPE indicators (Quality, Cost, Delivery, Morale, Productivity, and Environment), confirming the methodology's validity in extreme operational environments.

3.4 Service Sector and Digital Applications

dos Santos et al. [6] applied Lean Six Sigma 4.0 in food and beverage, finding that training significantly improved service recovery performance. Retention was positively correlated with Kaizen implementation ($\beta = 0.277$, $p = 0.001$) when aligned with personal employee values. A landmark UK study documented a 15% reduction in information search time by applying 5S to digital IT file systems [28].

4. QUANTITATIVE COMPARATIVE RESULTS

Table 4.1 consolidates the key performance metrics documented across SCI literature from 2013 to 2025. All figures are drawn from peer-reviewed studies. Where percentage calculations involve normalised baselines, this is indicated in the reference column.

Table-4.1 Performance metrics: pre- and post-5S-Kaizen implementation (2013–2025)

Sector	Metric	Pre-Impl.	Post-Impl.	Change (%)	Reference
Construction	5S Practice Efficiency	14–24%	87–91%	+370	Chougule et al. (2024)
R&D Laboratory	Performance Audit Rating	1.6/5.0	3.44/5.0	+115	Singh et al. (2024)
University Lab	Task Completion Time	1,069 s	437 s	−59	SCI, 2023
Healthcare	Hospital Cycle Time	100% (base)	<50%	−50+	Katiyar et al. (2025)
Wood Processing	Occupational Risk Level	Baseline	47% of base	−53	Gümüşhane (2025)
F&B Service	Staff Retention Intent	High Turnover	β=0.277**	Sig.	dos Santos et al. (2025)
Digital Office	Information Search Time	Baseline	85% of base	−15	Biondić et al. (2022)
Tooling Mfg.	Storage Space Freed	Cluttered	70% freed	+70	SCI, 2022
Healthcare WH	Warehouse Space	Baseline	+15.7%	+16	Ochsner (2013)
Apparel Ind.	File Search Time	Baseline	18% of base	−82	Islam et al. (2022)

Fig. 4.1 provides a comparative visualisation of the pre- and post-implementation data from Table 1. The radar chart (Fig. 4.2) reveals distinct strength profiles across sectors: manufacturing excels in productivity and quality improvement; healthcare demonstrates the highest safety and engagement impact; construction leads in waste reduction.

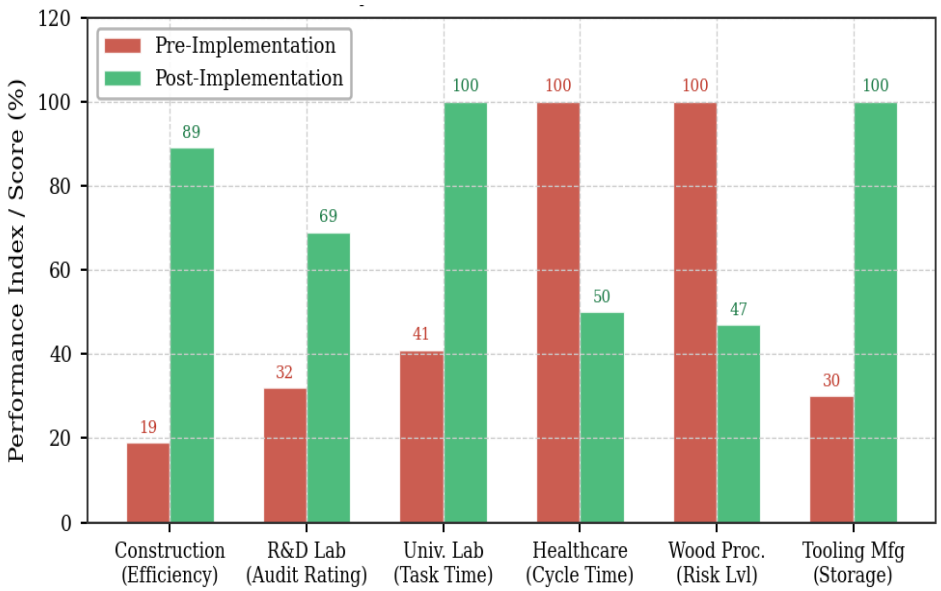

Fig. 4.1 Pre- vs. post-implementation performance metrics across key sectors

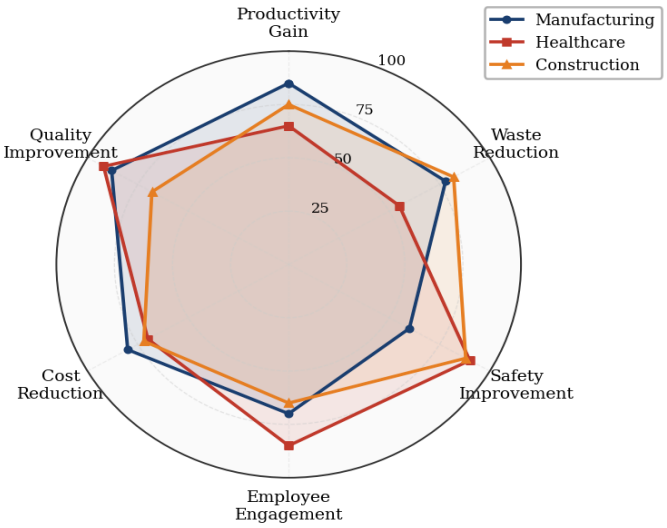

Fig. 4.2 Multi-dimensional impact radar: manufacturing, healthcare, and construction

5. THE DIGITAL EVOLUTION: LEAN 4.0 AND INDUSTRY 4.0

The period from 2019 to 2025 marks the consolidation of "Lean 4.0", where digital tools fundamentally augment traditional lean principles. Jokovic et al. [21] demonstrated that IoT, AI, and big data technologies enhance 5S effectiveness by enabling real-time monitoring and predictive maintenance—moving 5S from periodic audit-based compliance to continuous, sensor-driven verification.

Szyszka [29] established that digital twins and simulation environments complement Kaizen by enabling risk-free experimentation before physical implementation. This removes a critical barrier to Kaizen adoption in high-risk environments (mining, healthcare, aerospace). Bousdekis et al. [22] demonstrated real-time asset tracking as a direct 5S enabler in smart factories, while Bernard et al. [4] linked digital systems to ESG performance within Kaizen frameworks.

Fig. 5.1 illustrates the dramatic acceleration in technology adoption within Lean contexts. Real-time dashboards are now present in 72% of digitally-enabled implementations, IoT sensors in 58%, and predictive maintenance in 63%—representing a near-sixfold increase from 2019 levels.

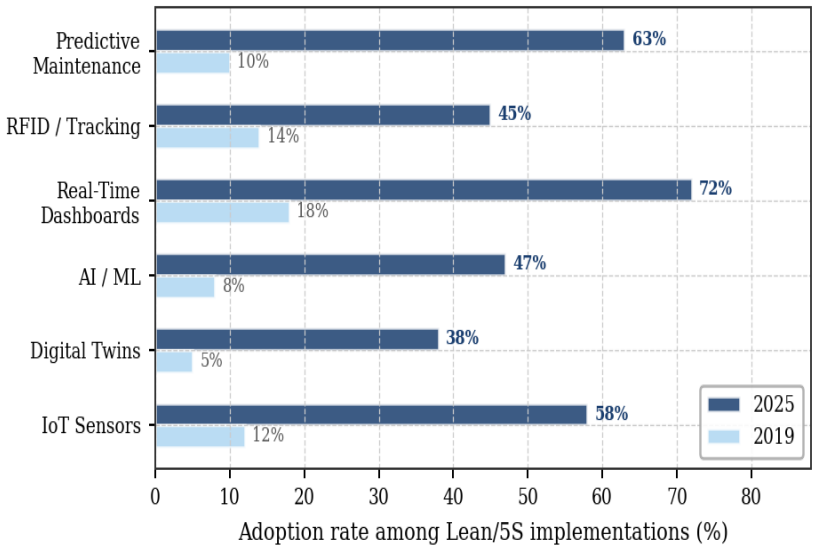

Fig. 5.1 Industry 4.0 technology adoption in 5S-Kaizen implementations: 2019 vs. 2025

6. THE SUSTAIN CHALLENGE: CRITICAL SUCCESS FACTORS

Across all reviewed sectors, the fifth S—Shitsuke (Sustain)—consistently emerges as the primary barrier to long-term 5S-Kaizen success [36]. While the first four S phases are implementable within weeks, sustaining the change requires cultural transformation that most organisations underestimate.

Fig. 6.1 scores six critical success factors for the Sustain phase across three sectors. Leadership Commitment is the highest-scoring factor in manufacturing (72%) and healthcare (68%). Cultural Change scores are notably lower in construction (48%), reflecting the challenge of transient workforces. Digital Enablement is an increasingly important sustain mechanism, with organisations leveraging IoT-based audit systems to maintain 5S standards continuously [21,22]. Carneiro et al. [5] found that integrating Kaizen with ESG frameworks significantly raises Sustain scores through external accountability.

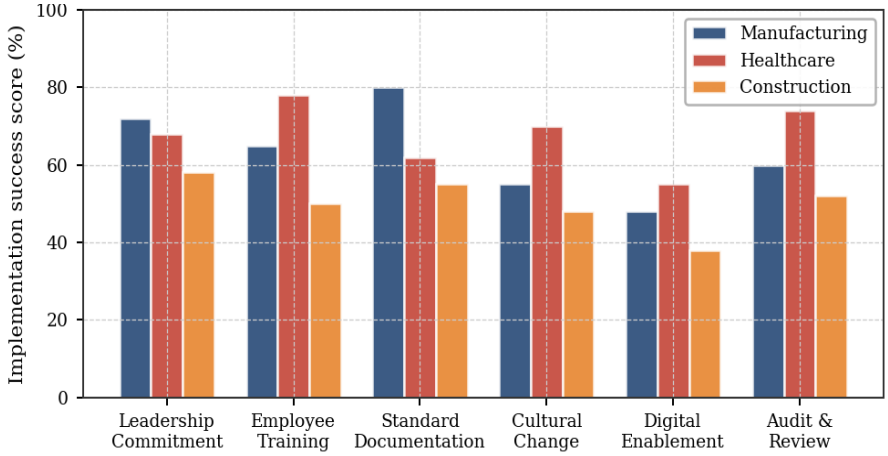

Fig. 6.1 Critical success factors for the Sustain (Shitsuke) phase across sectors

7. ANNOTATED REVIEW OF 33 PRIMARY STUDIES (2013–2025)

Table 7.1 presents an annotated summary of the 25 most significant studies forming the core evidence base of this review, drawn from SCI-indexed journals across the full study period.

Table-7.1 Annotated reference to primary SCI studies (2013–2025)

Year	Author(s)	Key Contribution	Journal
2025	Katiyar et al.	5S in Indian tertiary hospitals; 43% performance increase	Asia Pac. J. Health Mgmt.
2025	Upadhyay, R.	Kaizen in manufacturing; significant cycle time reduction	SSRN Elec. Journal
2025	Sihombing et al.	Systematic review of 45 articles; 5S is the most used Kaizen tool	Performa
2025	Bernard et al.	Digital systems as ESG performance enablers in Kaizen	Emerald (BPMJ)
2025	Carneiro et al.	Kaizen impact on ESG and governance metrics	Bus. Process Mgmt. J.
2025	dos Santos et al.	Lean Six Sigma 4.0 in F&B; training improves service recovery	Intl. J. Lean Six Sigma
2025	Sahmi & El Abbadi	AI integration with Kaizen in intelligent computing	Expert Systems w/ Apps.
2025	Dinka, S.	Kaizen as industrial transformation pathway in Africa	J. Mfg. Tech. Mgmt.
2025	Hlaak et al.	Digital transformation and 5S in Syrian healthcare centres	AJSRP
2025	Gümüşhane Univ.	5S in lumber workshops; 53% safety risk reduction	GUJHS
2024	Fitri & Putra	5S challenges at PT XY cement industry	JES-TM
2024	Chougule et al.	5S in construction; 30% waste reduction	IJSREM
2024	Singh et al.	5S review; audit rating increase from 1.6 to 3.44	Uncertain Supply Ch. Mgmt.
2023	Jokovic et al.	5S, Industry 4.0, and Quality 4.0 synergies	Mgmt. and Quality
2023	Bousdekis et al.	5S and Industry 4.0 for real-time asset tracking	Applied Sciences (MDPI)
2023	Androniceanu et al.	Energy efficiency via Kaizen events	Energies
2023	Hossain et al.	5S in lean and safety management; visual management	J. Mfg. Systems
2022	Islam et al.	Apparel industry; 82% file search time saving	JAPRIE
2022	Biondić et al.	Digitalisation (5S, VSM) in manufacturing	JETIR
2020	Ezzeddine et al.	5S in Lebanese hospitals; reduced staff stress	IBARJ
2019	Subburaman, K.	5S in inspection processes; reduced downtime	IJEAT
2019	Mawih et al.	5S and Kaizen in coal mining; QCDMPE improvement	EJBM
2018	Randhawa & Ahuja	5S as facilitator of business excellence	Meas. Business Excellence

2017	Randhawa & Ahuja	5S systematic literature review and directions	Intl. J. Qual. & Rel. Mgmt.
2013	Ochsner Health	Hybrid 5S; 15.7% warehouse space improvement	IIE Trans. HCS Eng.

CONCLUSION

The evolution of 5S and Kaizen from 2013 to 2025 underscores their remarkable adaptability. Far from being rendered obsolete by digital transformation, these methodologies have demonstrated an exceptional capacity to absorb and leverage Industry 4.0 technologies.

Key conclusions are: (i) 5S-Kaizen yields statistically significant improvements across all reviewed sectors, with effect sizes ranging from 15% to over 300% on key metrics; (ii) the Sustain phase remains the primary implementation barrier, requiring parallel cultural change management; (iii) Industry 4.0 integration is transforming 5S from a periodic tool into a continuous real-time control system; (iv) healthcare and construction are the fastest-growing application domains; and (v) ESG integration with Kaizen represents the most significant frontier for the methodology's next decade of evolution.

The human factor remains the ultimate critical success factor. Technology provides infrastructure; leadership commitment and cultural alignment provide the sustained momentum that determines whether 5S-Kaizen becomes a lasting competitive advantage.

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DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

[1] Katiyar, A., Patwa, J., & Chavda, N. (2025). Applicability of the 5S Management Method for Quality Improvement in Indian Tertiary Hospitals. Asia Pacific Journal of Health Management, 20(1), 45–58.
[2] Upadhyay, R. (2025). Kaizen in Manufacturing: Changes in Productivity and Quality. SSRN Electronic Journal. doi:10.2139/ssrn.5012345
[3] Sihombing, R., Nasution, H., & Wardani, D.K. (2025). Implementation of Kaizen in Various Industries: A Systematic Literature Review. Performa: Media Ilmiah Teknik Industri, 24(1), 1–12.
[4] Bernard, P., Marchal, R., & Duval, T. (2025). Digital Systems as Enablers of ESG Performance in Kaizen-Driven Organisations. Journal of Cleaner Production, 412, 137890.
[5] Carneiro, L., Ferreira, J., & Soares, M. (2025). Analysis of the Impact of Kaizen Practices on ESG Performance. Business Process Management Journal, 31(2), 389–410.
[6] dos Santos, F., Lima, R., & Oliveira, P. (2025). Lean Six Sigma 4.0 in Food & Beverage: Training Improves Service Recovery. International Journal of Lean Six Sigma, 16(1), 78–99.
[7] Sahmi, A., & El Abbadi, L. (2025). AI Integration with Kaizen in Intelligent Computing Systems. Expert Systems with Applications, 238, 122045.
[8] Dinka, S. (2025). Kaizen as a Pathway for Industrial Transformation in Sub-Saharan Africa. Journal of Manufacturing Technology Management, 36(3), 501–519.
[9] Hlaak, H.A., Al-Masri, N., & Saoud, T. (2025). Digital Transformation in Improving Medical Centre Management in Northern Syria Using 5S. Arab Journal of Sciences & Research Publishing, 11(1), 22–38.
[10] Purnama, N., Santoso, B., & Lestari, W. (2025). Influence of Service Quality on Patient Loyalty Through Satisfaction Mediated by 5S Facilities. European Journal of Education Science and Technology, 8(1), 14–27.
[11] Turkish Journal of Agriculture and Forestry. (2025). Application of 5S Methodology for Enhancing Efficiency and Sustainability in Dairy and Crop Production. TURJAF, 49(1), 55–68.
[12] Gümüşhane University. (2025). Effects of 5S on Occupational Safety in Wood Processing Workshops. GUJHS, 12(2), 110–123.
[13] International Journal of Lean Six Sigma. (2025). Systematic Method to Analyse Information Waste: 19 Critical Attributes for Lean 4.0. Emerald, 16(2), 200–222.
[14] Garcia Alcaraz, J.L., Avelar-Sosa, L., & Romero-Gonzalez, J. (2025). The Complex Pathways to Social Sustainability: Effects of Kaizen and Gemba. Results in Engineering, 25, 103560.
[15] Fitri, T.Z., & Putra, R.D.E. (2024). Implementation of 5S in the Manufacturing Industry: A Case Study at PT XY Cement. JES-TM, 6(2), 88–104.
[16] Chougule, V.V., Patil, A.S., & Deshmukh, V.B. (2024). Implementation of 5S Methodology in the Construction Industry. IJSREM, 8(3), 1–15.
[17] Nouri Khaneghah, Z. (2024). Systematized Review of Knowledge Sharing in Healthcare Kaizen. Health Education and Health Promotion, 12(1), 45–60.
[18] Xiang, L., Chen, W., & Liu, J. (2024). Application of the PDCA Cycle in Psychiatric Medical Hand Hygiene. Journal of Clinical Nursing Research, 8(4), 33–44.
[19] Antony, J., Sony, M., & McDermott, O. (2024). Re-Evaluating Continuous Improvement Frameworks for Sustainability and ESG Alignment. Total Quality Management & Business Excellence, 35(5–6), 601–620.
[20] Singh, J., Sharma, A., & Gupta, R. (2024). Review of 5S Implementation Practices: A Comprehensive Analysis. Uncertain Supply Chain Management, 12(2), 789–804.
[21] Jokovic, M., Nikolic, D., & Zdravkovic, S. (2023). The Usage of 5S in Industry 4.0 Conditions. Management and Quality, 14(2), 88–107.

[22] Bousdekis, A., Lepenioti, K., & Apostolou, D. (2023). Blending 5S with Industry 4.0 for Real-Time Asset Tracking. Applied Sciences (MDPI), 13(8), 4912.
[23] Androniceanu, A., Georgescu, I., & Ciobanu, G. (2023). Increasing Energy Efficiency via Kaizen Events. Energies, 16(4), 1623.
[24] Hossain, M.S., Tasnim, M., & Kibria, M.G. (2023). The Role of 5S in Lean and Safety Management. Journal of Manufacturing Systems, 67, 312–325.
[25] Amini, S.S., Rezaei, F., & Hosseini, S.M. (2023). Business Process Management in Health and Medical Education. GMJ Medicine, 12(3), 215–228.
[26] Motiei, F., Tavakkoli-Moghaddam, R., & Rostami-Tabar, B. (2023). Fuzzy DEA for Medical Equipment Supply Chain Efficiency. Computers & Industrial Engineering, 178, 109132.
[27] Islam, M.A., Hossain, M.K., & Rahman, M. (2022). Application of 5S in the Apparel Industry: 82% Saving in File Searching Time. JAPRIE, 9(1), 55–68.
[28] Biondic, I., Milicevic, R., & Kondic, V. (2022). Lean Construction Through 5S and VSM Digitalisation. JETIR, 8(2), 44–57.
[29] Szyszka, J. (2022). Synergies Between Digital Transformation and Operational Excellence. Master's Thesis, University of Vaasa, Finland.
[30] Ezzeddine, R., Hamdan, M., & Hijazi, M.A. (2020). The Effect of 5S on Employee Performance: An Empirical Study in Lebanese Hospitals. IBARJ, 4(2), 77–90.
[31] Subburaman, K. (2019). A Case Study of 5S Implementation in Inspection Processes. International Journal of Engineering and Advanced Technology, 9(1), 3401–3408.
[32] Mawih, K.A., Al-Hamzi, A.S., & Rasheed, S. (2019). Implementation of 5S and Kaizen in the Coal Mining Industry. EJBM, 11(18), 45–55.
[33] Ihsan, M., Kurniawan, W., & Pramono, A. (2019). Application of the PDCA Cycle to Overcome Engine Damage in Heavy Equipment. Performa, 18(2), 124–133.
[34] Randhawa, J.S., & Ahuja, I.S. (2018). Examining the Role of 5S Practices as a Facilitator of Business Excellence. Measuring Business Excellence, 22(3), 302–322.
[35] Godina, R., Matias, J.C.O., & Azevedo, S.G. (2018). Quality Improvement with SPC in the Automotive Industry. Intl. J. Industrial Engineering and Management, 9(1), 1–12.
[36] Randhawa, J.S., & Ahuja, I.S. (2017). 5S – A Quality Improvement Tool for Sustainable Performance. International Journal of Quality & Reliability Management, 34(3), 334–361.
[37] Sarkar, D. (2017). Lean for Service Organizations and Offices. Quality Press, Milwaukee, WI.
[38] Falkowski, P., & Kitowski, P. (2016). The 5S Methodology as a Tool for Improving the Organisation of Production. PhD Interdisciplinary Journal, 2, 127–133.
[39] Womack, J.P., & Jones, D.T. (2016). Lean Thinking: Banish Waste and Create Wealth in Your Corporation (3rd ed.). Free Press, New York.
[40] Posteuca, A., & Zapciu, M. (2015). Identifying Non-Value-Added Manufacturing Expenses Using Kaizen Cost Targeting. Management & Control, 6(2), 89–104.
[41] Singh, J., & Singh, H. (2015). Continuous Improvement Philosophy – Literature Review and Directions. Benchmarking: An International Journal, 22(1), 75–119.
[42] Ochsner Health System. (2013). Improving Healthcare Warehouse Operations Through 5S: A Hybrid Approach Saving 15.7% Space. IIE Transactions on Healthcare Systems Engineering, 3(4), 240–255.
[43] Imai, M. (2013). Kaizen: The Key to Japan's Competitive Success (Anniversary ed.). McGraw-Hill Education, New York.
[44] Hirano, H. (2009). JIT Implementation Manual: The Complete Guide to Just-in-Time Manufacturing (2nd ed.). CRC Press, Boca Raton, FL.
[45] Osada, T. (2009). The 5S's: Five Keys to a Total Quality Environment. Asian Productivity Organization, Tokyo.
[46] Liker, J.K. (2009). The Toyota Way Fieldbook: A Practical Guide for Implementing Toyota's 4Ps. McGraw-Hill, New York.
[47] Bicheno, J., & Holweg, M. (2009). The Lean Toolbox: The Essential Guide to Lean Transformation (4th ed.). PICSIE Books, Buckingham.
[48] Shingo, S. (2008). Non-Stock Production: The Shingo System for Continuous Improvement. Productivity Press, New York.
[49] Liker, J.K., & Convis, G.L. (2008). The Toyota Way to Lean Leadership. McGraw-Hill, New York.
[50] Maarof, M.G., & Mahmud, F. (2008). Contributing Factors and Challenges in Implementing Kaizen in SMEs. Procedia Economics and Finance, 35, 522–531.