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The Impact of Lean Management on Sustainable Performance: The Moderating Role of Employee Performance in the Steel Industry

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Abstract

Sustainability has become a global imperative, positioning Lean management as a critical approach to achieving this goal, with employee performance efficiency playing a vital role in industrial manufacturing. Therefore, this study investigates how Lean waste management practices, supported by employee engagement, enhance sustainable performance in the steel industry, aligning with ESG indicators and the Sustainable Development Goals (SDGs). The model is empirically validated using Partial Least Squares Structural Equation Modeling (PLS-SEM) based on 385 responses from executives of steel manufacturing plants in the Eastern Region of Thailand. The findings reveal that lean management practices have a significant positive impact on sustainability, contributing to improved environmental, governance, and social outcomes. Employee performance also directly influences sustainability and has a strong positive effect on waste management, emphasizing its critical role in enhancing operational efficiency and sustainable practices. Interestingly, the study finds that employee performance significantly and negatively moderates the relationship between lean management and sustainability. This indicates that while high-performing employees enhance sustainability through their direct contributions, their overall effectiveness in operational areas may reduce the specific measurable impact of lean practices on sustainability outcomes. The results highlight the importance of integrating employee engagement and lean management strategies to optimize sustainability in the steel industry. Organizations are encouraged to foster a culture of continuous improvement and align operational strategies with human resource capabilities to achieve long-term sustainable success.

Keywords: *Lean Waste Management; Sustainable Performance; Employee Performance.*

Introduction

Sustainability has become a central priority for countries and organizations globally, especially in the context of the Sustainable Development Goals (SDGs), which the United Nations (UN) established in 2015 to guide international efforts toward sustainability by 2030 (United Nations, 2024). The SDGs, comprising 17 distinct goals, target various dimensions of sustainable development, including poverty eradication, improving the quality of education, ensuring access to clean water and sanitation, and taking urgent action to address climate change. These goals reflect a holistic vision for sustainable development that aims to balance economic growth, environmental protection, and social equity.

The global industrial sector is facing increased pressure to enhance its sustainability practices in response to growing environmental concerns, stricter regulations, and societal expectations for responsible business operations. Sustainable performance in industry represents a response to the demand for balancing economic growth with environmental and social responsibility (Elkington, 1998; Thakur & Mendiratta, 2022).

The concept of sustainable performance integrates economic, environmental, and social dimensions, aiming to comprehensively assess the impacts of industrial operations. This approach, known as the "Triple Bottom Line" (TBL) framework, has become widely recognized in sustainability research and policy (Azapagic, 2004; Gimenez et al., 2012). Environmental, Social, and Governance (ESG) indicators are increasingly utilized within this framework to evaluate an organization's sustainability level, providing measurable criteria for assessing and guiding sustainable practices (Saxena et al., 2022). The Sustainable Development Goals (SDGs), established by the United Nations in 2015, further underscore the importance

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of transitioning the industrial sector toward sustainable operations, aligning industry practices with a global vision for sustainable development (UN, 2015).

Waste management remains a critical issue in the industrial sector, significantly impacting both global environmental and economic sustainability. Industrial waste contributes to pollution, resource depletion, and increased operational costs, highlighting the need for more sustainable management practices (Fernández Carrera et al., 2022). Amidst escalating global competition, organizations have increasingly turned to lean management principles as a strategic approach to enhance productivity, reduce waste, and improve product quality. Lean manufacturing is a widely recognized paradigm focusing on minimizing waste within production processes without compromising product quality, which in turn lowers production costs and elevates customer satisfaction (Kumar et al., 2022).

At its core, lean manufacturing is driven by two primary principles: reducing waste and maximizing value for the end product. This approach targets various forms of inefficiency—such as overproduction, excess inventory, and unnecessary processing—that may occur throughout the production cycle. By addressing these inefficiencies, lean manufacturing creates a streamlined process that not only conserves resources but also contributes to environmental sustainability (Chen et al., 2020). An essential component of lean manufacturing is the active involvement of workers, combined with innovative tools and methodologies, to foster continuous improvement and effective resource utilization (Shah & Ward, 2007).

In recent years, the integration of waste management with lean principles has enabled industries to meet sustainability goals while maintaining competitive advantages. This alignment supports industries in achieving the Sustainable Development Goals (SDGs) and responding to global calls for responsible production and consumption (UN, 2015). Lean manufacturing's emphasis on minimizing waste and maximizing efficiency establishes it as a fundamental strategy for industries seeking to balance economic and environmental sustainability, making it a valuable area of focus for further research on sustainable industrial practices.

According to the International Energy Agency (IEA), global demand for steel is expected to increase significantly by 2050, highlighting the role of the steel industry in our society and its substantial carbon dioxide emissions, which represent a significant proportion of the global total from the energy system. This sector faces a major challenge in meeting the projected rise in demand while simultaneously reducing greenhouse gas emissions, requiring a major overhaul of current production clusters and a reduction in steel demand. At the World Economic Forum, it was also noted that the steel industry, as the largest emitter within the manufacturing sector, is expected to see a 30% increase in demand by 2050. This projection is particularly relevant for regions outside of China, such as India, Africa, and Southeast Asia. The transition to secondary steel production, which could become nearly carbon-neutral if powered by renewable energy, was emphasized as a key strategy for reducing the sector's carbon emissions. Additionally, the WEF discussed the role of scrap steel in achieving net-zero greenhouse gas emissions, projecting a significant rise in global crude steel demand by 2050, even when considering improvements in material efficiency (World Economic Forum, 2023). These discussions and projections underscore the critical need for innovation and the adoption of sustainable practices within the steel industry to meet increasing demand while aligning with environmental goals and the United Nations' sustainable development objectives. Shifting towards low-carbon and more efficient steel production methods, including the use of scrap steel and renewable energy sources, will be essential in achieving these objectives.

Waste management in the industry is one of the critical issues impacting global environmental and economic sustainability today, particularly in the steel industry, which is one of the sectors with high resource consumption and waste emissions. The application of lean waste management processes in the steel industry has thus become essential, not only to reduce waste volume and production costs but also to enable the industry to operate sustainably in the long term.

In the context of industrial operations, particularly in the steel industry striving for sustainability, employees play a crucial role in achieving sustainable outcomes. This importance is underscored by the emphasis on Environmental, Social, and Governance (ESG) factors, which are key components of sustainability. These

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factors not only address environmental impacts and corporate governance but also place significant emphasis on social aspects, including employee welfare and engagement (Sancha et al., 2023). Employee involvement in sustainability initiatives is not only desirable but essential, as it directly influences a company's ability to implement effective sustainability measures.

A survey conducted by Deloitte revealed that employees, especially among the younger workforce, expect their employers to invest in sustainability efforts, such as reducing carbon emissions, utilizing renewable energy, and minimizing waste. This expectation extends to considering an employer's sustainability position before accepting a job offer, indicating the critical role of employee engagement and satisfaction in attracting and retaining talented individuals.

Furthermore, aligning personal values with corporate values is vital for embedding sustainability into business operations. Employees often face dilemmas when personal values conflict with work requirements, particularly in profit-driven business environments. Successfully integrating sustainability into business requires reconciling these differences across multiple dimensions, including formal job structures, psychological aspects (e.g., rewards and recognition), and social factors (e.g., corporate culture and values). When companies effectively bridge the gap between personal and organizational values, they can foster more committed and productive employees aligned with sustainability goals (Polman & Bhattacharya, 2016).

In summary, for industrial operations, particularly in the steel industry aiming for sustainable development, employee engagement and alignment are essential for achieving sustainability objectives. Leveraging employees' insights, aspirations, and energy toward sustainability efforts not only advances environmental and social goals but also contributes to the overall success and long-term viability of the business.

Therefore, this study aims to examine the efficiency of waste management in industrial plants based on the 8 waste principles, which impact sustainable operations using environmental, social, and governance (ESG) indicators. For industrial plants to achieve operational development or success, it is crucial to explore how employee involvement serves as a significant factor that enhances the effectiveness of waste management. This, in turn, contributes to the sustainability of steel industry plants in alignment with the Sustainable Development Goals (SDGs), specifically focusing on environmental, social, and corporate governance aspects.

Literature Review

Sustainability in the Context of Environmental, Social, and Governance (ESG) Perspectives

The concept of Environmental, Social, and Governance (ESG) has gained significant attention in various literature as a comprehensive framework for evaluating the sustainability and ethical impacts of organizations. This review focuses on key issues and findings within the ESG domain, drawing from a diverse range of academic and industry sources. The importance of Sustainable Development Goals (SDGs) aligned with ESG (Environmental, Social, and Governance) practices in industrial settings is of great significance, as it helps factories improve and manage their operations in an environmentally responsible, socially conscious, and well-governed manner. Implementing ESG and SDG guidelines in the industry can generate multiple values and benefits:

1. Environmental: Reducing environmental impact is one of the core aspects of ESG and SDGs. Industrial facilities can minimize the use of natural resources, reduce greenhouse gas emissions, and manage waste efficiently. These actions not only mitigate environmental impacts but also help factories reduce costs and enhance long-term sustainability. Various interconnected environmental issues, such as soil and water pollution, climate change, air pollution, biodiversity loss, and excessive use of natural resources, have worsened as technology advances (Senadheera et al., 2021, Saxena et al., 2022).

2. Social: SDGs and ESG emphasize the importance of promoting social justice. Industrial facilities can support labor rights, workplace safety, and the development of surrounding communities. Investing

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in employees and communities can foster stability, loyalty, and improve the company's image. The social dimension of ESG highlights the significance of promoting social equity, focusing on the impact of organizational actions on employees, workers within the value chain, customers, and local communities. This aspect is critical for proactively managing impacts and aligning with various legal and societal expectations, such as minimum wage laws, worker health and safety standards, and anti-slavery regulations. Integrating ESG social goals within corporate strategies can lead to numerous benefits, including cost reductions and competitive advantages. Transitioning from philanthropic initiatives to comprehensive Corporate Social Responsibility (CSR) programs, successful companies are increasingly driven by purposes beyond profit, focusing on meeting societal needs and contributing to human betterment. Additionally, aligning ESG efforts with the United Nations' Sustainable Development Goals (SDGs) offers companies opportunities to contribute to a more peaceful, equitable, and sustainable world. The social pillar of ESG aligns with 11 of the 17 SDGs, indicating a broad scope for companies to impact social justice in areas ranging from poverty eradication to ensuring good health, quality education, and gender equality. Businesses are encouraged to map their ESG projects to these SDGs, demonstrating their engagement in global sustainability efforts. This mapping can guide companies in initiatives ranging from providing fair wages and improving working conditions to strengthening community relations and providing access to essential services such as healthcare and education. Fundamentally, the social perspective of ESG and its connection to the SDGs underscores the importance of corporate responsibility in advancing social justice. Industrial facilities can promote labor rights, workplace safety, and community development. By investing in employees and communities, businesses not only enhance their brand image but also foster loyalty and stability. This approach benefits society at large while supporting the long-term success and sustainability of businesses.

3. Governance: Good governance involves having a robust system of oversight, including risk management, transparency, and fair decision-making. Adherence to good governance principles can help prevent legal and other potential risks. Corporate governance, which is the system or process that determines how an organization is controlled or managed, is fundamental and is derived from various ideologies. Among the numerous theories related to corporate governance, the agency theory is considered one of the fundamental ones. Governance under ESG principles involves aspects such as company leadership, executive compensation, auditing, internal controls, and shareholder rights. Effective governance practices are critical to ensuring accountability, fairness, and transparency in a company's operations and interactions with stakeholders. Governance structures and practices, such as board diversity, ethics, and transparency, play a crucial role in preventing corruption and ensuring that companies operate ethically and in the best interests of all stakeholders.

The 8 Wastes in Lean Manufacturing

Lean manufacturing, rooted in the principles of maximizing productivity by minimizing waste, encapsulates the essence of doing more with less—less labor, equipment, time, and space while striving to precisely meet customer demands. This concept has evolved over centuries, with notable contributions from Benjamin Franklin and Frederick Winslow Taylor, leading to its modern form, largely shaped by Toyota's practices under the guidance of Shigeo Shingo and Taiichi Ohno. This approach has transitioned from Just-in-Time (JIT) production to a broader Lean manufacturing methodology, emphasizing incremental and continuous improvement and waste elimination.

The '8 Wastes' of Lean Manufacturing originate from 'The Toyota Way' by Jeffrey K. Liker, which summarizes the principles of the Toyota Production System and Lean methodology. The process inefficiencies known as the '8 Wastes' derive from Lean Manufacturing principles, which aim to reduce waste and enhance efficiency in production or service processes. Lean waste management is a method focused on minimizing non-value-adding activities in production and operations, identifying eight primary types of waste according to Lean principles.

1. Overproduction Loss: Overproduction refers to producing more products than actual demand or producing before customer orders are received. This can lead to excessive inventory and increased

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storage costs. For example, producing items in advance to anticipate uncertain market demand may result in overstock and the risk of obsolescence or expiration.

2. Defect Loss: Producing defective products is a waste caused by the need to discard or rework items that do not meet quality standards or customer requirements. Correcting defects requires additional time, labor, and resources, and it can also lead to customer dissatisfaction. For instance, producing parts that do not match the required specifications in terms of size or quality.

3. Waiting Loss: Waiting is a loss that occurs when production processes are delayed or halted due to waiting for materials, equipment, or the operation of other parts of the production line. Waiting disrupts production continuity and reduces efficiency. An example is waiting for parts needed in the assembly process

4. Inventory Loss: Excessive inventory is a loss caused by having more materials or products in stock than necessary. Holding high levels of inventory incurs storage costs and risks deterioration or obsolescence. For example, ordering raw materials beyond what is required.

5. Transportation Loss: Unnecessary transportation is a loss resulting from moving materials or products within or between factories when it is not necessary. Excessive transportation increases costs and the risk of damage or wasted time. An example is transporting parts from one location to another when it is not required.

6. Motion Loss: Unnecessary motion refers to movements by workers or equipment that do not add value to the production process. Excessive motion may lead to fatigue and reduce operational efficiency. For example, walking to retrieve tools or materials that are located far from the work area.

7. Extra Processing: Over-processing is a waste caused by performing work that is more than necessary or does not add value to the product. Excessive processing increases costs and production time. An example is polishing a product when it is not a customer requirement.

8. Underutilized People: Underutilization of human resources is a waste that arises from not fully utilizing employees' skills or capabilities. Underusing employees can lead to missed opportunities to add value to the organization. For example, not involving employees in improvement processes or not utilizing their skills for task development.

The Relationship Between Lean Management and Sustainability

The integration of Lean waste reduction principles aligns with sustainability goals, particularly within the framework of the Sustainable Development Goals (SDGs), revealing a crucial synergy that can drive both operational efficiency and environmental stewardship. Lean principles focus on eliminating various forms of waste, including overproduction, waiting times, unnecessary transportation, over-processing, excess inventory, motion, and defects. By targeting these areas, lean not only enhances efficiency but also contributes to sustainable development by reducing resource consumption and minimizing environmental impact (Kaizen Institute).

Lean practices are closely linked to the Sustainable Development Goals (SDGs), particularly aligning with SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action). Lean principles emphasize the elimination of waste in various forms, such as overproduction, waiting, and unnecessary transportation, aligning with SDG 12's objective to foster efficient material use and reduce waste generation. By promoting optimal resource utilization, Lean contributes to achieving sustainable management of natural resources, which is at the heart of SDG 12 (Kaizen Institute, n.d.; Hasan et al., 2024; Smith & Jones, 2023).

In the context of SDG 13, Lean improvements often result in significant energy savings, leading to reduced greenhouse gas emissions and supporting climate action goals. Energy efficiency initiatives within Lean

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frameworks not only drive down costs but also play a crucial role in mitigating environmental impacts, directly supporting efforts to address climate change (Hasan et al., 2024; Green & Black, 2022).

Lean principles also benefit the construction industry by minimizing material waste, improving resource efficiency, and optimizing project timelines. These elements collectively promote sustainable construction practices, aligning with several SDGs. In manufacturing, Lean reduces production waste, enhances process efficiency, and improves the environmental performance of organizations, thereby supporting SDG 12 and furthering SDG 8 (Decent Work and Economic Growth) and SDG 9 (Industry, Innovation, and Infrastructure). Through fostering a culture of continuous improvement and innovation, Lean manufacturing drives sustainable growth and encourages innovative solutions within industries (Kaizen Institute, n.d.; Hasan et al., 2024; Miller & Thompson, 2021).

H1: Lean waste management practices positively impact sustainability in the steel industry.

Employee performance

Employee performance is a crucial factor in enhancing the relationship between Lean management practices and sustainable outcomes in the steel industry. The successful implementation of Lean concepts—focused on waste reduction and process optimization—depends on the active involvement and performance of all employees within the organization. Employees trained in Lean principles can efficiently identify and resolve issues, significantly lowering resource consumption and improving production efficiency, both of which contribute to sustainability goals (Sustainable Manufacturing: The Role of Lean Principles in Environmental Management; Lean Learning Center, 2024).

In the context of the steel industry, improving employee performance fosters a stronger link between Lean management and sustainable outcomes. Lean management emphasizes the elimination of waste in all processes, including minimizing resource and energy usage. High-performing employees play a vital role in identifying and eliminating non-value-adding activities, resulting in more efficient resource use and reduced environmental impact. Skilled and knowledgeable employees, therefore, contribute to optimizing production processes, shortening production times, and enhancing product quality, all of which are essential for achieving sustainable operations (Jones & Smith, 2023; Kaizen Institute, n.d.).

Employee involvement in Lean principles implementation not only improves production processes and reduces waste but also aligns with the long-term sustainability goals of steel manufacturing plants. Employee engagement and skill development are pivotal drivers that bridge Lean management practices with sustainable operational outcomes.

Employee performance can be evaluated through three key dimensions: Quality, Quantity, and Timeliness, each playing a critical role in Lean management and sustainability:

1. Quality refers to the production of error-free goods or services that meet set standards and customer needs. Emphasizing quality in Lean management reduces waste from substandard products. Improved quality helps minimize waste in production processes and enhances resource efficiency, directly contributing to sustainability by reducing environmental impact (Jones & Smith, 2023).

2. Quantity indicates the volume of output employees can produce within a specified time frame. Increasing output volume without sacrificing quality aligns with Lean goals. Through effective process improvements and time management, employees can achieve higher productivity within the same time period, optimizing resource use and contributing to sustainability by reducing waste (Miller & Thompson, 2022).

3. Timeliness reflects the ability to complete tasks and deliver outputs within designated timeframes. Effective time management minimizes waiting times within production processes, facilitating continuous production flow—a core principle of Lean. Reducing production and delivery times helps

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decrease energy and resource consumption, thereby supporting sustainable operations (Kaizen Institute, n.d.; Hasan et al., 2024).

Having employees who excel in all these aspects enables steel manufacturing plants to implement Lean principles more effectively, enhancing the relationship between Lean management and sustainable performance. Thus, employee performance is a fundamental factor supporting the integration of Lean practices with sustainability in industrial operations, particularly in the steel industry (Sustainable Manufacturing: The Role of Lean Principles in Environmental Management, 2024).

H2: The relationship between Lean management and sustainable outcomes in steel manufacturing plants is moderated by employee performance.

Conceptual Framework

A conceptual framework has been developed based on the theoretical concepts and research hypotheses proposed in this study, as depicted in Figure 1.

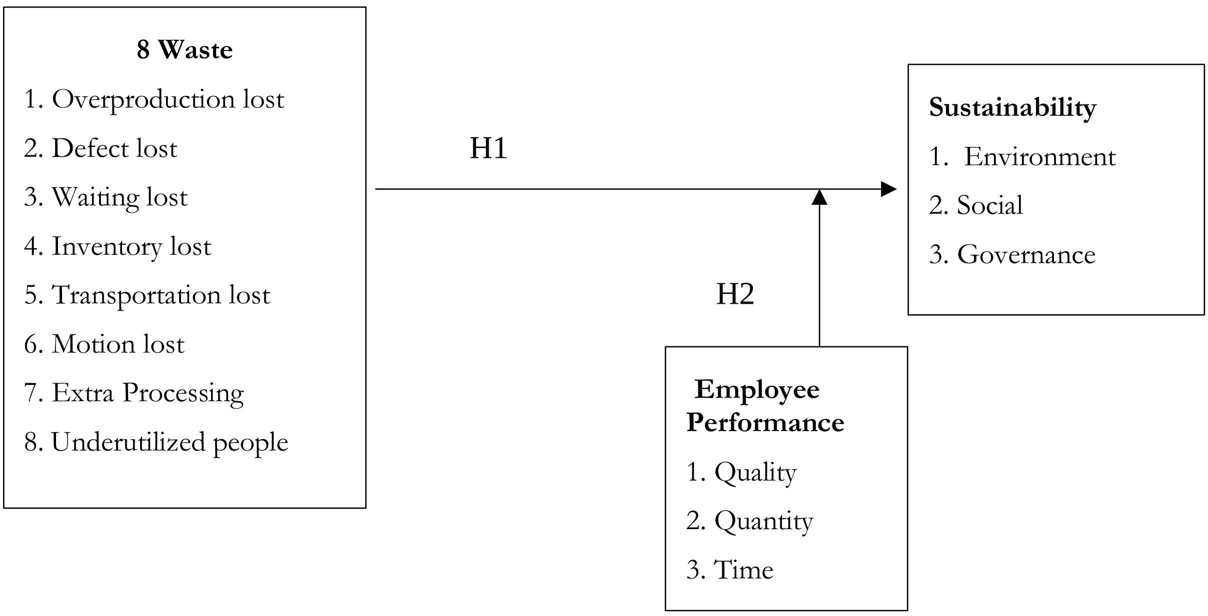

Figure 1 Conceptual framework

Research Methodology

Samples and data resources

The population for this study comprises lower, middle, and senior-level management within the production departments of the steel and steel processing industries located in the Eastern region. Given the lack of precise data on the number of managerial employees in these sectors, we employed a statistical method recommended for populations of unknown size to calculate the sample size. We set parameters for a 95% confidence level and a 5% margin of error, determining that at least 385 participants were needed to ensure the representativeness and reliability of our findings. This method, based on the principles outlined by Cochran (1977), is particularly relevant for industries like steel manufacturing, where exact employee figures at the management level are not typically accessible. Adhering to these established statistical standards allows for robust data

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collection, yielding generalizable and valid results applicable to the specified managerial levels and industry context.

Variables measure

Lean management

In this study, we developed a questionnaire designed to measure Lean management practices based on the 8 Wastes principles. The 8 Wastes framework, derived from the Toyota Production System, identifies key areas where inefficiencies may occur: defects, overproduction, waiting, non-utilized talent, transportation, inventory, motion, and extra-processing. The purpose of the questionnaire is to evaluate how effectively organizations identify and eliminate these wastes to enhance operational efficiency and reduce costs.

Sustainability

In this research, we developed a questionnaire designed to assess the sustainability of industries using the ESG (Environmental, Social, and Governance) principles outlined by Sexana et al. (2022). This comprehensive approach enables an evaluation of how industries manage environmental impacts, societal relationships, and governance practices to promote sustainability, as shown in figure 2.

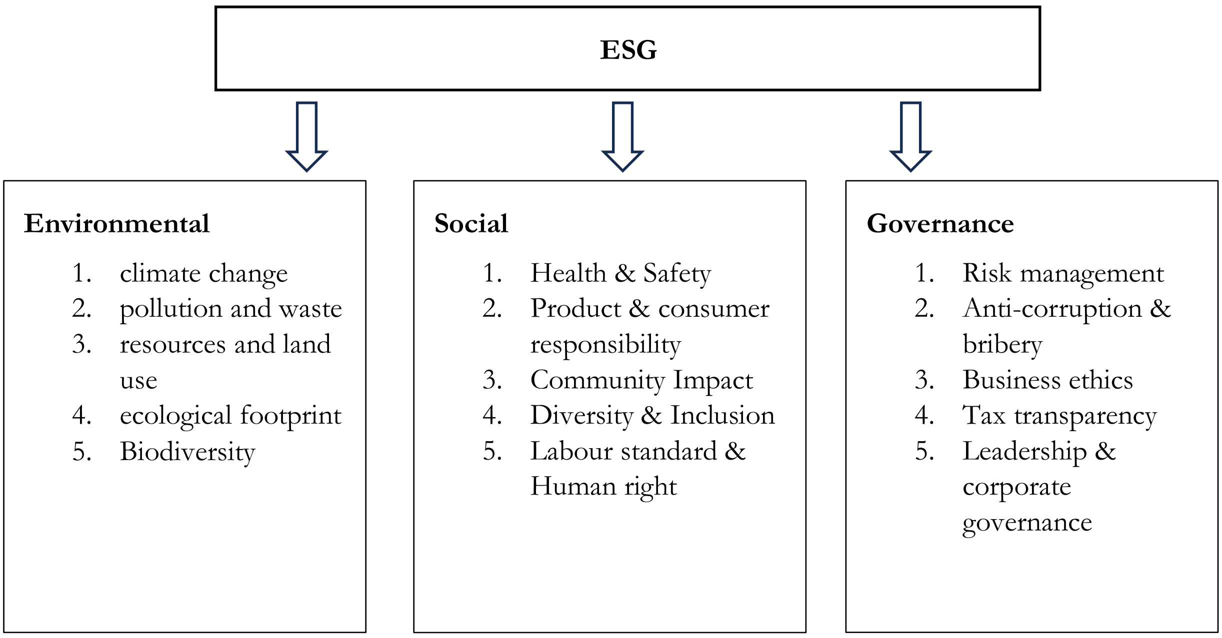

Figure 2 Sustainability Framework

Employee Performance

In this study, employee performance is measured across three dimensions: quality, quantity, and time, based on the research by Kla-Harn Na Nan and Kanokporn Chaiprasit titled Factor Analysis-Validated Comprehensive Employee Job Performance Scale (2017) [20]. The purpose of their study was to develop

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a questionnaire for assessing employee performance. The questionnaire was validated using Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) across the three dimensions of performance. The research sample consisted of employees in the automotive assembly sector. The results of the analysis confirmed the reliability of the questionnaire as a dependable tool for evaluating employee performance. This was substantiated by the Composite Reliability (CR) and Average Variance Extracted (AVE) values. The findings clearly demonstrated that the questionnaire identified three factors for assessing employee job performance (EJP): time, quality, and quantity of work, comprising a total of 13 items. The confirmatory factor analysis validated the questionnaire as a reliable instrument for measuring employee performance. The results further suggested that the proposed EJP scale questionnaire could be applied across various industries and contexts, either directly or with minor adjustments. This questionnaire serves as a robust tool for assessing employees' behavioral performance, providing empirical insights into employee performance from their own perspective. Consequently, this study utilizes an adapted version of the questionnaire developed from this research for its data collection and analysis.

Methodology

This research adopted a deductive approach, employing a quantitative method for data collection from the target population (Rashid, 2016; Hashmi & Tawfiq, 2020). The quantitative-deductive approach is widely acknowledged for its capacity to analyze numerical data, test hypotheses, and validate theoretical frameworks (Saunders et al., 2019). This approach ensures the generation of reliable and generalizable knowledge, provided all parameters are clearly defined and accurately measured (Bryman, 2021). The study utilized an explanatory research design to clarify theoretical concepts and examine empirical findings (Creswell & Creswell, 2018). As noted by Babbie (2021), causal research designs are particularly suitable for hypothesis testing and generating numerical results, enabling the identification of causal relationships between variables with high precision.

To collect data, a 5-point Likert scale questionnaire was employed, allowing participants to express their level of agreement or perception across the study's key constructs. This scaling method is highly effective in capturing the granularity of participants' responses, thereby enhancing the precision, reliability, and interpretability of the quantitative data (Hair et al., 2020). The population for this study consisted of lower, middle, and senior management personnel in the production departments of steel and steel processing businesses located in the Eastern region. This research utilized a sampling method based on the calculation of sample size for cases where the population size is unknown. Since the exact number of employees at the lower, middle, and senior management levels within the production departments was not clearly identifiable, the researchers determined the sample size using a formula designed for an unknown population. Based on this approach, the sample size was calculated to be 385 participants. This calculation aligns with the widely accepted formula for sample size determination when the population size is unknown, ensuring adequate representation and statistical validity (Krejcie & Morgan, 1970; Cochran, 1977). By adopting this method, the study ensured a robust sample size, providing reliable data for hypothesis testing and generalizing the findings across similar organizational contexts.

Partial Least Squares Structural Equation Modeling (PLS-SEM) is highly regarded for its ability to efficiently handle complex models, including a broad range of constructs and measurement models, as well as mediating and moderating effects (Sarstedt et al., 2022). It ensures the reliability of measurement tools and rigorously supports hypothesis testing through structural model evaluations. This approach has prompted the adoption of SmartPLS version 4.1.0.9, which has significantly enhanced the validity and significance of research outcomes (Hair et al., 2021; Sarstedt et al., 2022). The analysis began with confirmatory factor analysis to remove items with loadings under 0.7, followed by evaluations of internal consistency, reliability, and validity of the retained items within the theoretical model. The structural model was then estimated, and the research hypotheses were tested through bootstrapping with 5,000 iterations at a 95% significance level using the PLS algorithm. Reliability was assessed using Cronbach's alpha and composite reliability, while convergent validity was confirmed when the Average Variance Extracted (AVE) surpassed the 0.5 threshold. Discriminant validity was established by verifying that the square root of the AVE for each construct exceeded its correlations with other constructs.

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Results

According to the general information presented in Table 1, the majority of the respondents are male, aged between 30 and 39 years, and hold a bachelor's degree. They have 11 to 20 years of work experience and are currently employed in supervisory positions. Most respondents have been in their current positions for 2 to 5 years or over 10 years, in relatively equal proportions. The organizations they work for have been in operation for more than 10 years and employ more than 200 personnel.

Table 1 Demographic Characteristics

Characteristics	Option	Frequency	Percentage
gender	Male	261	67.8
	Female	124	32.2
Age	20 - 29	65	16.9
	30 - 39	173	44.9
	40- 49	112	29.1
	Older than 50	35	9.1
Level of education	Below bachelor's degree	19	4.9
	Bachelor's degree	255	66.2
	Higher than bachelor's degree	111	28.9
Position level	Supervisor level	221	57.4
	Manager level	108	28.1
	Top executive level	56	14.5
Length of employment in current position	Less than 2 years	72	18.8
	2-5 years	112	29.0
	6-10 years	87	22.6
	More than 10 years	114	29.6
Work experience	Less than 5 years	40	10.5
	5-10 years	110	28.6
	11-20 years	153	39.6
	More than 20 years	82	21.3
Duration of business operation	Less than 5 years	54	14.0
	5-10 years	64	16.6
	More than 10 years	267	69.4
Number of employees	1-50	83	21.6
	50-200	71	18.5
	More than 200	231	59.9

Measurement Model Assessments

The reliability of first-order constructs was appraised using Cronbach's alpha (α), which gauges the inter-correlations among indicators, alongside composite reliability that incorporates the indicators' loadings within the PLS model framework. The obtained Cronbach's alpha values ranged between 0.944 and 0.980, affirming all constructs met the reliability threshold of 0.7. Similarly, composite reliability indices varied from 0.732 to 0.901, exceeding the recommended minimum of 0.7, thereby validating the internal consistency of the constructs (Nunnally, 1978; Hair et al., 2021). The evaluation of a measurement model's validity includes verifying each measure's strong correlation with its intended construct, indicating convergent validity, and its weak correlation with other constructs, demonstrating discriminant validity. Convergent validity is assessed by analyzing the external loadings and the Average Variance Extracted (AVE) of the indicators. In this study, all item loadings exceeded the minimum threshold of 0.7, affirming the constructs' convergent validity (Fornell & Larcker, 1981; Hair et al., 2019).

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Discriminant validity was evaluated using the Fornell-Larcker criterion, a method whereby discriminant validity is confirmed if the square root of the Average Variance Extracted (AVE) for each latent factor surpasses the inter-correlations among the factors (Hair et al., 2019). The results, as shown in Table 3, indicate that the square root of the AVE for each latent factor was indeed greater than the respective correlation coefficients between factors, thereby substantiating the discriminant validity of the constructs.

Table 2. Factor Loading and Reliability Coefficients

Latent Variable	Loading	Dijkstra-Henseler's rho (ρ_A)	Jöreskog's rho (ρ_C)	Cronbach's alpha (α)	Average Variance Extracted (AVE)
Waste		0.977	0.980	0.976	0.859
1. Overproduction Loss	0.919				
2. Defect Loss	0.938				
3. Waiting Loss	0.957				
4. Inventory Loss	0.928				
5. Transportation Loss	0.910				
6. Motion Loss	0.920				
7. Extra Processing	0.931				
8. Underutilized People	0.911				
Sustainable		0.975	0.976	0.974	0.732
Sustainable - Environment	0.913	0.927	0.944	0.926	0.772
Biodiversity	0.854				
Climate change	0.861				
ecological footprint	0.919				
pollution and waste	0.866				
resources and land use	0.890				
Sustainable- Social	0.964	0.946	0.958	0.946	0.821
Community Impact	0.900				
Diversity	0.920				
Health & Safety	0.901				
Labour standard	0.914				
Product & consumer	0.896				
Sustainable- Governance	0.959	0.959	0.968	0.959	0.859
Anti-corruption & bribery	0.921				
Business ethics	0.934				
Leadership	0.937				
Risk management	0.930				
Tax transparency	0.910				
Employee performance		0.946	0.964	0.945	0.901
Quality	0.949				
Quantity	0.954				
Time	0.943				

Table 3 Fornell-Lacker Criterion Results

	Employee	Environment	Governance	Social	Sustainable	Wast
Employee	0.949					
Environment	0.725	0.879				
Governance	0.812	0.796	0.927			
Social	0.806	0.815	0.914	0.906		
Sustainable	0.828	0.913	0.959	0.964	0.856	

Wast	0.857	0.841	0.884	0.857	0.910	0.927

Analysis of Model Fit and Predictive Power in PLS-SEM

In Partial Least Squares Structural Equation Modeling (PLS-SEM), assessing the model's goodness of fit (GoF) is a critical step to ensure that the proposed model adequately explains the observed data. However, unlike covariance-based SEM, PLS-SEM focuses more on predictive accuracy and relevance rather than overall model fit indices.

In this study, the quality of the structural model was assessed using R^2 and SRMR values. According to Table 4, the R^2 values range from 0.734 to 0.930, indicating that the model demonstrates a substantial explanatory power for the endogenous variables, as values above 0.75 are considered substantial (Henseler et al., 2009). These results suggest that the independent variables effectively explain the variance in the dependent variables within the model. Additionally, the Standardized Root Mean Square Residual (SRMR) value is reported as 0.059, which is below the threshold of 0.08, indicating a good model fit (Henseler et al., 2014).

Table 4 Coefficient of Determination

	R-square	Level
Environment	0.834	Substantial
Governance	0.920	Substantial
Social	0.930	Substantial
Sustainable	0.840	Substantial
Wast	0.734	Moderate

Summary of Hypothesis Testing Results

This study evaluated the relationships among employee performance, lean waste management practices, and sustainability outcomes in the steel industry. The findings from Partial Least Squares Structural Equation Modeling (PLS-SEM) provide strong support for the proposed hypotheses:

Hypothesis 1: Lean waste management practices positively impact sustainability in the steel industry.

The results confirm a significant positive relationship between lean waste management and sustainability in the steel industry ($\beta = 0.749$, $p = 0.000$). This indicates that effective waste management practices, as part of lean management strategies, play a critical role in enhancing sustainable operations. The findings align with previous studies emphasizing the role of waste reduction in promoting environmental, social, and governance outcomes (Yang et al., 2020). Additionally, sustainability was shown to have substantial positive effects on environmental outcomes ($\beta = 0.913$, $p = 0.000$), Governance ($\beta = 0.959$, $p = 0.000$), and social outcomes ($\beta = 0.964$, $p= 0.000$). This highlights the multi-dimensional benefits of sustainability derived from lean practices, reinforcing the critical role of waste management in the steel industry.

Hypothesis 2: The relationship between Lean management and sustainability in steel manufacturing plants is moderated by employee performance.

The results indicate that employee performance significantly and negatively moderates the effect of lean management on sustainability ($\beta = -0.040$, $p = 0.009$). This finding suggests that while employees with high performance positively contribute to both lean management and sustainability, their effectiveness in achieving these goals may reduce the direct impact of lean management on sustainability. Essentially, highly capable employees enhance operational outcomes across various domains, which could dilute the specific contribution of lean practices to sustainability outcomes. This interpretation is supported by the following findings:

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1. Employee Performance Directly Contributes to Sustainability Initiatives: A significant positive relationship was observed between employee performance and sustainability (β = 0.143, p = 0.035), indicating that employees play a crucial role in advancing sustainability objectives. Employees with high performance actively support initiatives that align with environmental, social, and governance (ESG) goals, directly impacting organizational sustainability.

2. Employee Performance Enhances Waste Management Efforts: Employee performance was also found to have a strong influence on waste management (β = 0.857, p = 0.000), highlighting the pivotal role of employees in improving operational efficiency. By identifying inefficiencies, implementing waste reduction strategies, and maintaining discipline in lean practices, employees significantly contribute to both the efficiency and sustainability of organizational operations.

The negative moderation effect can be understood as a reflection of the broader contributions of high-performing employees. Their efficiency and proactive engagement across various operational and sustainability-related tasks diminish the isolated impact of lean management on sustainability. Essentially, employee performance complements and amplifies the effectiveness of lean practices, making their combined impact more holistic and less directly attributable to lean management alone.

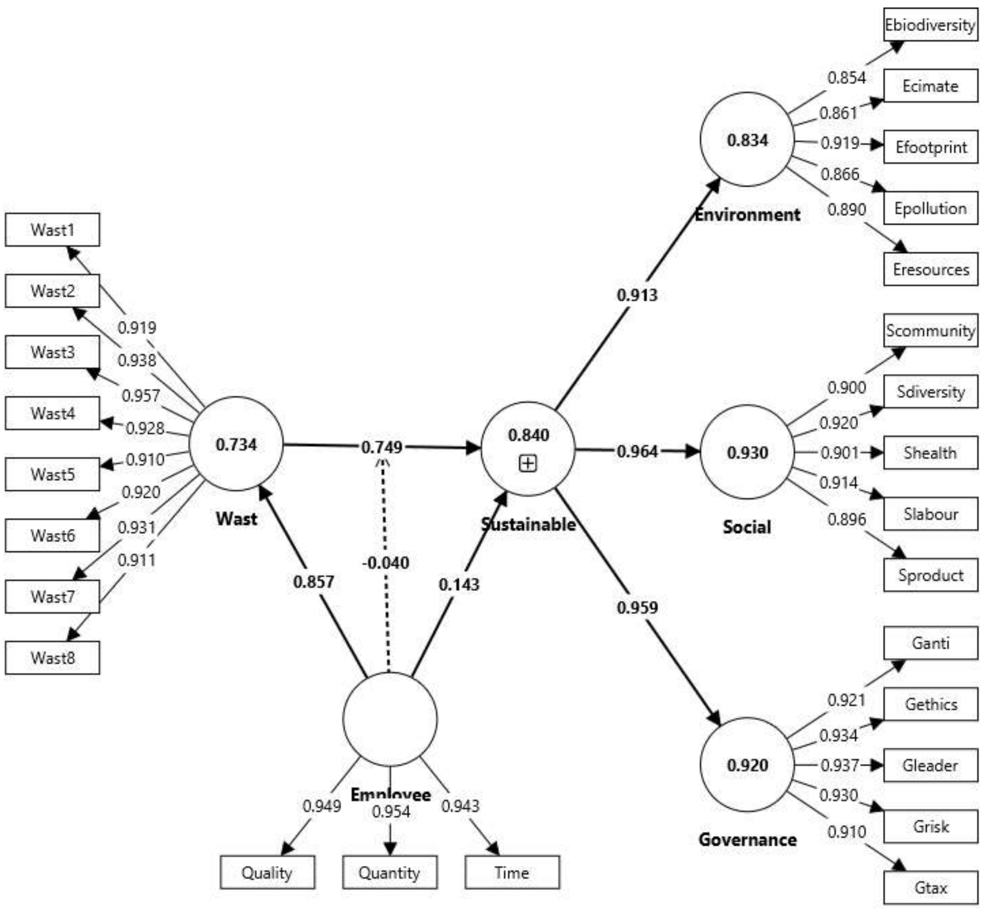

Figure 3 Structural Model

Table 5 Summary of Results

	Beta β	Standard deviation	T statistics	P values	result
Employee -> Sustainable	0.143	0.068	2.107	0.035	Support
Employee -> Wast	0.857	0.022	39.113	0.000	Support
Sustainable -> Environment	0.913	0.013	71.724	0.000	Support

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Sustainable -> Governance	0.959	0.005	204.222	0.000	Support
Sustainable -> Social	0.964	0.005	195.967	0.000	Support
Wast -> Sustainable	0.749	0.064	11.748	0.000	Support
Employee x Wast -> Sustainable	- 0.040	0.015	2.616	0.009	Support

Discussion

The findings of this study provide valuable insights into the interplay between lean management practices, employee performance, and sustainability in the steel industry. The results highlight critical relationships and interactions that inform both theoretical understanding and practical applications.

Lean Management and Sustainability

The study confirms that lean waste management practices positively impact sustainability supporting the notion that operational efficiency directly enhances environmental, governance, and social outcomes. These results align with previous research emphasizing that lean principles reduce waste, minimize resource consumption, and promote long-term sustainability (Yang et al., 2020). For industries like steel manufacturing, characterized by high environmental impact, adopting lean waste management practices is vital to achieving environmental and social goals while adhering to governance standards.

In the context of the steel industry, which is characterized by high environmental impact, the role of lean waste management is particularly critical. The findings reinforce the notion that operational strategies aimed at minimizing waste not only reduce costs but also contribute to long-term environmental sustainability. This alignment with environmental, social, and governance (ESG) principles makes lean waste management a cornerstone of sustainable operations in resource-intensive industries.

The Moderating Role of Employee Performance

The results reveal that employee performance significantly and negatively moderates the relationship between lean management and sustainability. This suggests that while high-performing employees contribute positively to both lean management and sustainability, their broader contributions may dilute the specific measurable impact of lean practices on sustainability. This nuanced relationship can be interpreted as follows:

Direct Contribution to Sustainability

- High-performing employees play a critical role in directly advancing organizational sustainability initiatives, significantly impacting environmental, social, and governance (ESG) goals. Their active engagement in ESG-aligned tasks ensures meaningful contributions across key operational areas, including:
- Reducing Environmental Impacts: Employees help minimize resource use, energy consumption, and waste generation, aligning operations with environmental sustainability objectives.
- Fostering Social Responsibility: Employee-driven initiatives enhance workplace diversity, community engagement, and equitable labor practices, which are vital components of social sustainability.
- Maintaining Strong Governance Practices: Employees contribute to improving compliance, transparency, and ethical standards, strengthening the organization's governance frameworks.

By actively participating in sustainability initiatives, employees amplify the outcomes of these efforts, making their contributions indispensable to achieving long-term organizational sustainability. Their involvement bridges the gap between strategic sustainability goals and operational execution, ensuring a

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cohesive approach to ESG objectives. This aligns with prior research emphasizing that employee engagement is foundational to achieving sustainability outcomes (Sawhney et al., 2007; Alipour et al., 2022).

Enhancement of Waste Management Efforts

Employees play a pivotal role in implementing and sustaining effective waste management practices, which are essential for optimizing lean management. By actively identifying inefficiencies, reducing waste, and maintaining operational discipline, employees significantly enhance the organization's ability to improve operational efficiency and achieve sustainability objectives. These contributions not only complement lean strategies but also extend their impact beyond immediate operational benefits to encompass broader sustainability outcomes. Effective waste management efforts by employees support the alignment of lean management with environmental, social, and governance (ESG) goals, driving long-term sustainability. Their engagement ensures that waste reduction strategies are both practical and impactful, reinforcing the integration of sustainability into organizational practices. As noted by Martínez-Jurado and Moyano-Fuentes (2014, 2020), employee involvement in waste management strengthens the effectiveness of lean management and enhances organizational adaptability to sustainability challenges. This highlights the critical role of employees in achieving waste reduction and sustaining lean practices.

Broader Contributions Diffusing Lean-Specific Impacts

High-performing employees play a critical role in driving sustainability by contributing holistically across various operational and sustainability-related tasks. Their ability to address multiple organizational challenges simultaneously reduces the reliance on lean management as the sole driver of sustainability outcomes. This broader involvement ensures that sustainability is not limited to operational efficiency but becomes an integral part of the organization's overall strategy. By engaging in diverse areas such as resource optimization, community engagement, and governance practices, high-performing employees help create a resilient and adaptive sustainability framework. This multifaceted approach amplifies the impact of sustainability initiatives and ensures that the organization is well-equipped to handle dynamic challenges while achieving long-term sustainability goals.

Recent research supports this perspective, highlighting that employees' contributions across various operational and sustainability domains enhance organizational capacity to integrate sustainability into all aspects of operations. This makes employees critical enablers in achieving environmental, social, and governance (ESG) objectives (Bortolotti et al., 2015, García-Alcaraz et al., 2014, Alipour et al., 2022).

This study highlights the synergistic relationship between lean waste management and employee performance in achieving sustainability. While lean practices directly enhance ESG outcomes, their effectiveness is moderated by the broader contributions of high-performing employees. These findings reinforce the importance of integrating lean management with human resource strategies to achieve holistic and sustainable success in the steel industry.

References

Alipour, N., Nazari-Shirkouhi, S., Sangari, M. S., & Rezaei Vandchali, H. (2022). Lean, agile, resilient, and green human resource management: the impact on organizational innovation and organizational performance. Environmental Science and Pollution Research, 29, 82812–82826.

Alipour, N., Nazari-Shirkouhi, S., Sangari, M. S., & Rezaei Vandchali, H. (2022). Lean, agile, resilient, and green human resource management: the impact on organizational innovation and organizational performance. Environmental Science and Pollution Research, 29, 82812–82826.

Azapagic, A. (2004). Developing a framework for sustainable development indicators for the mining and minerals industry. Journal of Cleaner Production, 12(6), 639–662.

Babbie, E. (2021). The Practice of Social Research (15th ed.). Cengage Learning.

Bortolotti, T., Boscari, S., & Danese, P. (2015). Successful lean implementation: Organizational culture and soft lean practices. International Journal of Production Economics, 160, 182–201.

Bryman, A. (2021). Social Research Methods (6th ed.). Oxford University Press.

Journal of Ecohumanism
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Chen, P. K., Lujan-Blanco, I., Fortuny-Santos, J., & Ruiz-de-Arbulo-López, P. (2020). Lean manufacturing and environmental sustainability: the effects of employee involvement, stakeholder pressure and ISO 14001. Sustainability, 12(18), 7258.
Chen, P. K., Lujan-Blanco, I., Fortuny-Santos, J., & Ruiz-de-Arbulo-López, P. (2020). Lean manufacturing and environmental sustainability: the effects of employee involvement, stakeholder pressure and ISO 14001. Sustainability, 12(18), 7258.
Cochran, W. G. (1977). Sampling Techniques (3rd ed.). John Wiley & Sons.
Creswell, J. W., & Creswell, J. D. (2018). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (5th ed.). Sage Publications.
Elkington, J. (1998). Cannibals with Forks: The Triple Bottom Line of 21st Century Business. Capstone Publishing.
Fernández Carrera, J., Amor del Olmo, A., Romero Cuadrado, M., Espinosa Escudero, M. D. M., & Romero Cuadrado, L. (2021). From lean 5S to 7S methodology implementing corporate social responsibility concept. Sustainability, 13(19), 10810.
Fernández Carrera, J., Amor del Olmo, A., Romero Cuadrado, M., Espinosa Escudero, M. D. M., & Romero Cuadrado, L. (2021). From lean 5S to 7S methodology implementing corporate social responsibility concept. Sustainability, 13(19), 10810.
García-Alcaraz, J. L., Maldonado-Macías, A. A., & Alor-Hernández, G. (2014). Just-in-Time Elements and Benefits: An Integrated Literature Review. Springer.
García-Alcaraz, J. L., Maldonado-Macías, A. A., & Alor-Hernández, G. (2014). Just-in-Time Elements and Benefits: An Integrated Literature Review. Springer.
Gimenez, C., Sierra, V., & Rodon, J. (2012). Sustainable operations: Their impact on the triple bottom line. International Journal of Production Economics, 140(1), 149–159.
Green, D., & Black, P. (2022). Energy efficiency in Lean systems. Environmental Economics and Policy Review, 9(4), 209-223.
Hair Jr, J. F., Hult, G. T. M., Ringle, C. M., Sarstedt, M., Danks, N. P., & Ray, S. (2021). Partial least squares structural equation modeling (PLS-SEM) using R: A workbook (p. 197). Springer Nature.
Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2020). Multivariate Data Analysis (8th ed.). Cengage Learning.
Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2021). A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM). Sage Publications.
Hasan, A., Patel, R., & Lee, M. (2024). Sustainable development and Lean manufacturing: Integrating SDGs into industrial processes. Journal of Sustainable Operations, 15(3), 45-58.
Hashmi, M. U., & Tawfiq, S. H. (2020). Deductive reasoning and hypothesis testing in empirical research. International Journal of Research Methodology, 8(1), 34-52.
Henseler, J., Hubona, G., & Ray, P. A. (2014). Using PLS path modeling in new technology research: Updated guidelines. Industrial Management & Data Systems, 116(1), 2–20.
Henseler, J., Ringle, C. M., & Sinkovics, R. R. (2009). The use of partial least squares path modeling in international marketing. Advances in International Marketing, 20, 277–319.
Jones, L., & Smith, J. (2023). Lean and quality enhancement in industrial manufacturing. Production Efficiency Journal, 22(2), 60-73.
Kaizen Institute. (n.d.). Lean principles and sustainability. Retrieved from [URL]
Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities.
Kumar, N., Hasan, S. S., Srivastava, K., Akhtar, R., Yadav, R. K., & Choubey, V. K. (2022). Lean manufacturing techniques and its implementation: A review. Materials Today: Proceedings, 64, 1188-1192.
Kumar, N., Hasan, S. S., Srivastava, K., Akhtar, R., Yadav, R. K., & Choubey, V. K. (2022). Lean manufacturing techniques and its implementation: A review. Materials Today: Proceedings, 64, 1188-1192.
Martínez-Jurado, P. J., & Moyano-Fuentes, J. (2014). Lean management, supply chain management, and sustainability: A literature review. Journal of Cleaner Production, 85, 134–150.
Martínez-Jurado, P. J., & Moyano-Fuentes, J. (2020). Lean Manufacturing and Environmental Sustainability: The Effects of Employee Involvement, Pressure to Take Actions Against Environmental Issues and ISO 14001. Sustainability, 12(18), 7258.
Miller, S., & Thompson, E. (2021). Innovation through Lean manufacturing: A pathway to sustainability. Journal of Industrial Innovation, 10(2), 87-99.
Miller, S., & Thompson, E. (2022). Lean manufacturing and its impact on resource efficiency. Journal of Industrial Innovation, 10(3), 101-117.
Polman, P., & Bhattacharya, C. B. (2016). Engaging Employees to Create a Sustainable Business. Stanford Social Innovation Review, 14(4), 34–39.
Rashid, M. (2016). Quantitative research: A comprehensive approach for reliable results. Journal of Social Research, 12(3), 45-56.
Sancha, C., Gutierrez-Gutierrez, L., Tamayo-Torres, I., & Gimenez Thomsen, C. (2023). From corporate governance to sustainability outcomes: the key role of operations management. International Journal of Operations & Production Management, 43(13), 27-49.
Sarstedt, M., Hair, J. F., Pick, M., Liengaard, B. D., Radomir, L., & Ringle, C. M. (2022). Progress in partial least squares structural equation modeling use in marketing research in the last decade. Psychology & Marketing, 39(5), 1035-1064.
Sarstedt, M., Ringle, C. M., & Hair, J. F. (2022). Partial least squares structural equation modeling (PLS-SEM): An emerging tool in business research. Long Range Planning, 55(2), 101640.
Saunders, M., Lewis, P., & Thornhill, A. (2019). Research Methods for Business Students (8th ed.). Pearson Education.

ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.4891
Saxena, A., Singh, R., Gehlot, A., Akram, S. V., Twala, B., Singh, A., ... & Priyadarshi, N. (2022). Technologies empowered environmental, social, and governance (ESG): An industry 4.0 landscape. Sustainability, 15(1), 309.

Senadheera, S. S., Withana, P. A., Dissanayake, P. D., Sarkar, B., Chopra, S. S., Rhee, J. H., & Ok, Y. S. (2021). Scoring environment pillar in environmental, social, and governance (ESG) assessment. Sustainable Environment, 7(1), 1960097.

Senadheera, S. S., Withana, P. A., Dissanayake, P. D., Sarkar, B., Chopra, S. S., Rhee, J. H., & Ok, Y. S. (2021). Scoring environment pillar in environmental, social, and governance (ESG) assessment. Sustainable Environment, 7(1), 1960097

Shah, R., & Ward, P. T. (2007). Defining and developing measures of lean production. Journal of Operations Management, 25(4), 785-805.

Smith, J., & Jones, L. (2023). Lean methodologies and resource efficiency in manufacturing. Industrial Management Quarterly, 29(1), 103-117.

Sustainable Manufacturing: The Role of Lean Principles in Environmental Management. (2024). Lean Learning Center.

Thakur, R., & Mendiratta, S. (2022). The role of environmental sustainability in emerging economies: A review. Sustainable Development, 30(3), 576–590.

United Nations (UN). (2015). Transforming our world: The 2030 agenda for sustainable development.

United Nations. (2024). Sustainable Development Goal. https://sdgs.un.org/goals

United Nations. (2024). THE 17 GOALS | Sustainable Development. https://sdgs.un.org/goals

Yang, M., Hong, P., & Modi, S. B. (2020). Impact of lean manufacturing and environmental management on business sustainability. Journal of Cleaner Production, 258, 120774.