

Building a Strong Future: Exploring the Synergy of Lean Production and Sustainable Manufacturing

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Abstract

Increased market growth of the FMCG industry is closely related to increased sales due to increased customer demand for products. The increase in production volume due to increased consumer demand has put the FMCG industry under pressure to play an active role in effectively reducing the environmental burden and help in preserving the environment. In addition, the increase in raw materials, energy and various environmental, safety, and social compliance, and the high expectations of stakeholders have resulted in the industry facing challenges and pressures. The implementation of lean production in the FMCG industry will encourage the achievement of manufacturing sustainability, which aims not only for the company's future success but also for the physical and mental health of generations to come. This research was conducted with literature studies and interviews with manufacturing experts. This research illustrates how the application of lean production can encourage the creation of sustainable manufacturing through the application of Value Stream Mapping (VSM), Just in Time (JIT), Total Productive Maintenance (TPM), Total Quality Management (TQM), Human Resources Management (HRM) and 5S which can encourage sustainability economically, environmentally, and socially. In its application, it is also necessary to analyze product Eco-Design as a prevention of product impact on the environment through product life cycle evaluation. The results of this research demonstrate a conceptual model framework for translating lean production practices into sustainable manufacturing. Future research can be expanded to include other indicators of sustainable manufacturing, such as technology improvement, digitalization utilization, and innovation of product and process.

Keywords: *lean production; sustainable manufacturing.*

1. Introduction

Industrial is one of the central positions and drivers for the economy of modern society, so it is necessary to make changes in the quality of development in order for development to be sustainable. Industrial ecology must be built to avoid industrial pressure on the environment because industry plans for energy resources and raw materials; therefore, to reduce the harmful influence on human health and the environment, resources must be used more efficiently, and waste and polluting sources must be created in smaller quantities. Additionally, a system must be established to manage the flow of energy and materials in order to obtain highly efficient value and produce less pollution (Tibbs, 1992). Industrial ecology seeks to enhance the efficiency of the material lifecycle,

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spanning from raw materials through the production of finished goods, the components of products, waste generated during the product life, to the ultimate disposal stage. A system must manage the energy and material flow in order to obtain high efficiency values and minimize pollution (Jelinski et al., 1992)

The government plays a role in encouraging the development of industrial ecology through building resilient infrastructure, increasing sustainable industry and strengthening innovation to help reduce social inequality in society. This is done because industry has a considerable impact on the environment, social, and economy. Sustainability, the junction of the three sections of the economic, environment, and society, is becoming an increasingly significant condition for human activity, making sustainable development a major aim in human progress (Rosen & Kishawy, 2012).

Due to its highly competitive nature and increasingly complex processes, manufacturing industry is cited as a major source of environmental degradation and other social problems. On the one hand, powerful machinery and technologies are replacing basic equipment. On the other hand, the globalization of ambitious client requirements compels enterprises to improve production processes. Lean principles are widely used by many manufacturers that focus on reducing waste but adding value to customers so that they can be more competitive. Lean production systems focus more on the economic side, but rarely take into account social and environmental sustainability (Ruben et al., 2018).

Increased consumer demand for products must be balanced with waste utilization and management. The role of industry is needed in reducing contamination by minimizing waste to the environment with several innovations and developments in raw materials and products, more environmentally friendly technology, and a system that encourages an industry to minimize waste. Contemporary industries recognize the necessity of using Lean manufacturing as a strategy for reducing waste, streamlining operations, and increasing added value. On the other hand, the industry also focuses on developing environmentally friendly products and processes. The application of Lean Production can provide a pathway to achieve sustainable benefits (Pradana et al., 2018).

Lean may also reflect a vision for sustainability by streamlining procedures, prices, time, waste, and quality. Other methods to sustainability emphasize environmental protection, trash re-use, and greenhouse gas emissions reduction. Sustainable development is required in the lean method, such as decreasing energy usage, reducing environmental pollution, and using raw materials that fulfil sustainable standards. Implications of sustainability can be found in lean production systems (Taucean et al., 2019). There are continuous improvement activities in all processes. The adoption of lean and sustainability ideas will complement one another due to their commonalities. By using these two approaches, a firm may attain better performance. Lean manufacturing can be integrated with Sustainable Manufacturing to optimize processes that result in improved environmental performance, occupational health, safety, and resource reduction. The shift from Lean to Sustainable manufacturing requires a change in thinking and decision-making with a more holistic approach that must consider the various dimensions of sustainability into manufacturing decision-making in a more balanced way (Ruben et al., 2018).

Suppliers, producers, customers, and other stakeholders create value in manufacturing via their activities and relationships. friendly manufacturing reacts to the market by developing lean, environmentally friendly products. In practice, sustainable manufacturing must balance environmental, social, and economic concerns. In practical terms, manufacturers need to enhance their commitment to environmental responsibility and sustainability without compromising on profitability and productivity. These aspects are now viewed as strategic objectives within manufacturing firms. As sustainability awareness grows, consumers will evaluate the overall value of a product, process, and organizational system using diverse metrics, including quality, service, social

sustainability, lead time costs, and ecological footprint throughout the product life cycle (Hariyani & Mishra, 2022). To achieve sustainable manufacturing, it is essential to integrate business strategies with manufacturing strategies to ensure that environmental and sustainability aspects are considered alongside economic factors in decision making. Sustainability indicators should be directly driven by business strategy. (Taghavi, 2015).

The Fast-Moving Consumer Goods (FMCG) industry market in Indonesia has increased by 7-9% every year. The increase in market growth in this industry is closely related to the increase in sales in several companies, both multinational and local companies. The amount of market demand is followed by increased development of new products and increased production to answer customer needs. (Deniarni & Lisnawati, 2016). Lean implementation research is not new on a worldwide scale, but there has been limited study, particularly in the FMCG companies in Indonesia. (Tanudiharjo et al., 2021) stated that lean implementation cannot be lucrative for FMCG companies unless crucial elements are properly managed. Management involvement and leadership are key drivers of lean implementation in Indonesia FMCG companies. Past research studies conducted by (Nurwulan, 2021) in the Indonesia's FMCG industry in the food and beverage sector explained that solid teamwork between workers is needed because effective communication will be able to create efficient processes. Successful implementation of lean not only benefits the company but also customers because the company can provide high quality products at low costs without reducing the added value provided to customers. (Wibowo, 2021) also discovered that continual improvement is the key to boosting performance in the FMCG business, which is complicated and has massive production volumes. In addition, research into the FMCG industry and warehouse operations in Saudi Arabia and the United States has resulted in a conceptual framework for Lean implementation. The identification of waste and the deployment of Lean techniques have a significant impact on the success or failure of Lean implementation in the FMCG business (Aljunaidi & Ankrak, 2014).

Lean promotes a sustainable vision of simplifying processes, prices, time, waste, and quality. In other words, sustainability focuses on environmental protection, repurposing trash, and lowering greenhouse gas emissions. Sustainable development, such as decreasing energy consumption, minimizing pollution, and using raw materials that adhere to sustainable principles, is required in the lean strategy. Lean manufacturing processes have sustainability consequences. Because they have many commonalities, the use of lean and sustainability ideas will complement one other. A company's performance may be enhanced by implementing these two principles (Tăucean et al., 2019).

2. Lean Production System

The main objective of Lean Production, an integrated socio-technical system, is to eliminate waste by simultaneously reducing or minimizing variations in supplier, customer, and internal processes. When suppliers don't deliver the appropriate amount or quality at the appropriate time or location, supply variability happens. By developing a stable and engaged supply base with a small number of important suppliers on long-term contracts, this fluctuation can be controlled. There are several methods and instruments that reduce process time variability. For example, describing work to the smallest detail allows for line balance and hence more predictable output numbers. Strict quality assurance decreases rework and leads to less variability in process time. personnel trained in multiple job areas can replace missing personnel without interrupting the flow, quality, and quantity of work (Shah & Ward, 2007).

The Lean idea is regarded as a business strategy whose primary goal is to grow the client base by optimizing resource utilization in order to eventually produce financial outcomes. Lean can, in reality, cut direct costs by 5%–20%, lead times by 80%, processing speed, reduce unfinished production (WIP) and 50%–80% of finished products; it can also

improve productivity, operational performance, and quality, reduce waste, increase operating profit by 5%, and make flexible production that uses labour, space, and resources efficiently. Three ideas can be used to summarize lean management techniques: cutting waste, preserving the quality of the product or service, and increasing output. There are several tools used in the application of Lean including Process mapping, Value Stream Mapping (VSM), Six Sigma, 5S, Cellular Manufacturing, Kanban System, JIT Concept, Kaizen Continuous Improvement, Standardisation, Total Quality Management (TQM), Total Productive Maintenance (TPM) (Florescu & Barabaş, 2018).

In further development, the concept of lean thinking in the execution of Lean Manufacturing may be applied in various fields and can be combined with various disciplines. The following are the five general principles of lean production (Zakuan & Saman, 2009):

- 1) Value: specific value of specific products from customer demand
- 2) Value Stream: recognizing and mapping out the journey of each product from its raw material stage to reaching the customer.
- 3) Flow: creating the seamless progression of value within a process, aiming to shorten lead time while ensuring high quality and low costs.
- 4) Pull System: implementing the Just-in-Time concept, where the flow of the process is customer-driven. This approach ensures that production is initiated based on actual customer demand, promoting efficiency and minimizing unnecessary inventory.
- 5) Perfection: the use of the notion of continual improvement at all times to achieve good outcomes.

Lean manufacturing may help a company save money by generating competitive advantages, minimizing waste costs, recruiting new consumers, and reducing management costs associated with environmental pollution reduction. Other study has examined the impact of lean manufacturing on social accountability, another aspect of sustainability. Several studies imply that lean manufacturing enhances the organization's social index via minimizing stress (Eskandari et al., 2022).

The financial, operational, and resource elements are the three primary categories of performance indicators that can be used to assess the effectiveness of lean production. When implementing it, financial health is crucial. Nonetheless, in order for activities to function more smoothly and performance to rise, improvements in waiting and cycle times must be achieved. The human element is more significant and the resource indicator is more concerned with altering the workplace culture (Bhadu et al., 2021).

3. Sustainable Manufacturing

Sustainable Manufacturing is characterized by the production of economically valuable goods using processes that minimize adverse effects on the environment, conserve energy and natural resources, and ensure their availability for the future. The executed processes must prioritize the safety of employees, communities, and consumers. Sustainable Manufacturing contributes to the establishment of sustainable development, aligning with the definition provided by the World Commission on Environment and Development. This type of development seeks to meet present needs without jeopardizing the ability of future generations to fulfil their own requirements. The concept of sustainability is intricately connected to the triple bottom line, where environmental, economic, and social considerations must be adequately addressed. Proper fulfilment of these three pillars is essential for a company's development and competitiveness without causing detrimental impacts on the environment (Rosen & Kishawy, 2012).

The objective of Sustainable Manufacturing is the ongoing integration of environmental enhancements into industrial processes and products, aiming to mitigate or prevent air, water, and soil pollution, minimize waste at its source, and decrease risks to both humans and other species. The challenges associated with implementing Sustainable Manufacturing include addressing consumer/customer demands for eco-friendly products, establishing effective recycling programs, reducing the use of raw materials, and selecting raw materials with minimal environmental impact. In terms of processes, Sustainable Manufacturing seeks to preserve raw materials and energy, eliminate the use of toxic substances, and decrease waste generation. Concerning products, the goal is to minimize environmental impacts throughout the entire product life cycle. The intersection between process and product perspectives arises because adopting a product life cycle approach necessitates consideration of the environmental impact of the manufacturing process as well. (Amaranti et al., 2017).

The primary strategy of Sustainable Manufacturing involves tackling environmental issues through regulation, precautionary measures, and responsible product management. The initial approach involves end-of-pipe treatment for various emissions, concentrating on the finished product. The second is prevention, which is centred on getting rid of pollution and emissions. Additional components or external and internal stakeholders who can support environmental changes are involved in product stewardship. The environmental effects of industrial processes and their full life cycle are the main focus of sustainable manufacturing. By organizing tactics, practices, and behaviours that strive to avoid, lessen, and eliminate harmful impacts on the environment, the concept is changing and giving rise to new ideas (Salvador et al., 2017).

Sustainable manufacturing is defined as "the creation of economically valuable products through processes that minimise negative impacts on the environment, save energy and natural resources, and conserve natural resources and energy to ensure their availability in the future." It is a methodology that is supported by Lean Manufacturing and Green Manufacturing (Jayal et al., 2010).

In order to execute sustainable manufacturing, an organization has to be aware of sustainability issues and include suppliers, consumers, and staff. The organization should concentrate on production design, function design, resource usage and economic design, design for the environment, recycling, and for social effect with entire life cycle assessment (LCA) if it wants to create sustainable products. The organization has to be involved in process planning as well as its execution. Because they are directly involved in manufacturing operations and are knowledgeable about workplace issues, employees possess significant potential to enhance system performance. As such, their ideas should be considered when designing new systems to guarantee the sustainability of processes, products, and systems (Hariyani & Mishra, 2022).

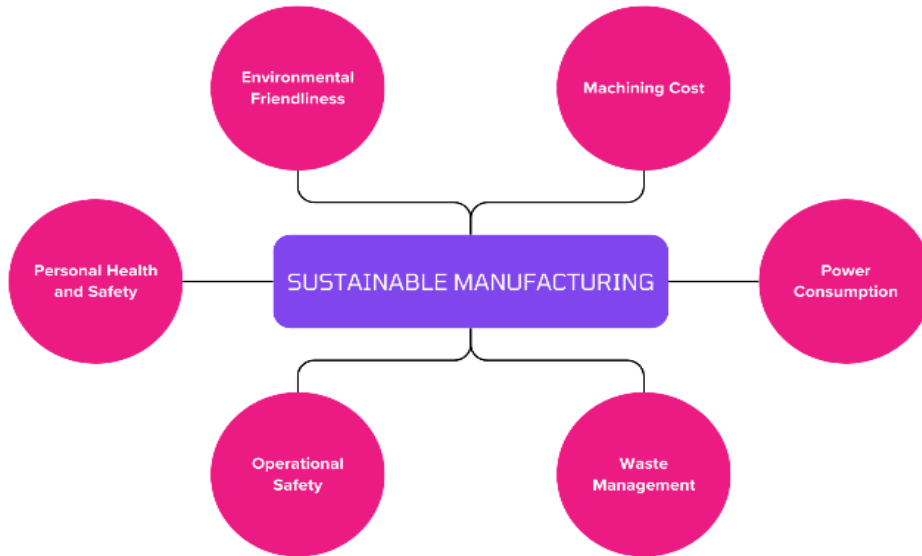


Figure 1. Sustainable Manufacturing Framework (Jayal et al., 2010)

The Sustainable Manufacturing framework seeks to promote environmental innovation, new technology development, and methodical answers to global environmental concerns while also accelerating sustainable industrial production through information dissemination, product and production process facilitation, and environmental innovation. In general, businesses aim to reallocate their financial, human, information, and physical resources so that the amount of money leaving the system exceeds the amount of money coming in. When making this reconfiguration, businesses must adhere to social and environmental goals and regulations in order to be considered sustainable (Rosen & Kishawy, 2012).

It is necessary to consider sustainability while evaluating products and procedures. Improving decision-making while optimizing product and process design is the primary objective of creating process and product metrics under the Sustainable Manufacturing concept. Alternatively, sustainable products are characterized as products that deliver economic, social, and environmental advantages while safeguarding public health, well-being, and the ecosystem throughout their complete life cycle, starting from raw material extraction to ultimate disposal (Lu et al., 2011).

4. Relationship between Lean Production and Sustainable Manufacturing

Lean production focuses on how to provide more value to customers while doing less labour by discovering and analysing if resources may be used for purposes other than giving value to the end consumer (Malgorzata et al., 2021). In the meantime, sustainable manufacturing is a procedural approach that results in heightened ecological compatibility, decreased expenditures, lowered energy usage, diminished waste accumulation, heightened operational safety, and enhanced employee well-being. The triple bottom line is one of the standards for achieving competitive advantage via sustainable manufacturing. This transformation to sustainable manufacturing necessitates a shift in thinking and decision-making from a conventional to a more holistic perspective (Badurdeen & Jawahir, 2017).

Lean is employed to create a comprehensive perspective on sustainability by integrating process efficiencies such as cost, time, and quality with sustainability principles, encompassing environmental quality, social justice, and economic well-being (Bae & Kim, 2007).

Lean Production and Social Indicator in Sustainable Manufacturing. In the process, social sustainability focuses on workers and society as a whole, such as providing equal employment chances for workers of all ages and genders, developing employee abilities via training, and providing employees with health and safety training (Khodeir & Othman, 2018). Workers are a vital asset for the company in all instances. Workers normally react favourably in the long run when it comes to expanding knowledge and abilities, but there are individuals who are terrified of change. Managers' roles are critical in changing attitudes. Worker conditions in terms of occupational health and safety improve as lean manufacturing methods such as Just in Time, 5S, Jidoka, and others are implemented. They may rely on broad perspectives, resulting in a more effective decision-making process. If the adoption of lean manufacturing fails, it will result in process inconsistencies and increased worker stress. This has the potential to cause work accidents (Resta et al., 2016).

Lean Production and Economic Indicator in Sustainable Manufacturing. The operational benefits of embracing lean manufacturing philosophy and methods include lower costs and greater quality, dependability, and flexibility. (Resta et al., 2016). The pillar of a sustainable economy focuses on an organization's role in increasing profits for itself and society. It does not focus on profit or profit as much as possible from the price and quantity of raw materials and manufacturing expenses, but rather on the quality created so that the items produced may bring additional value to consumers (Khodeir & Othman, 2018).

Lean Production and Environment Indicator in Sustainable Manufacturing. The correlation between lean manufacturing and environmental metrics in sustainable manufacturing is linked to the reduction of production process waste through optimizing raw material utilization, preventing product defects, and minimizing or eliminating the usage of hazardous and toxic substances (Eskandari et al., 2022). According to (Khodeir & Othman, 2018), environmental sustainability is achieved by minimizing waste in processes and products. Process waste might include energy, water, and resources. In addition, you may analyse process designs in light of technology advancements and create procedures to decrease product waste. When a company embarks on developing a new product, it must focus on product design, raw material selection, and conduct a life cycle analysis (LCA) to evaluate the entire product life cycle. This ensures that the forthcoming product is designed to minimize its environmental impact (Ranjan et al., 2021).

5. Indicator sets review

Various indicators can be arranged in a holistic sustainable manner. Various Lean Production indicators will be studied together to measure sustainability on a much larger scale than as individual indicators. The measurement results can help the Company create focus areas for continuous improvement.

6. Methodology

This research methodology is to study the relationship of lean production as a driver of the creation of Sustainable Manufacturing, especially in the FMCG industry. The method used in this research is a literature study and interviews from several experts in manufacturing. FMCG. An extensive literature review was conducted in the early stages of this research by identifying research gaps in this area.

7. Result and Discussion

In the manufacturing sector, particularly in industries with extensive production volumes like Fast-Moving Consumer Goods (FMCG), the environmental footprint emerges as a critical concern. Manufacturing companies are increasingly pressured to actively contribute to significantly reducing environmental impacts and contribute to environmental preservation. Not to mention the increase in raw materials, energy, various environmental, safety, and social compliance and higher expectations from stakeholders, resulting in the manufacturing industry facing challenges and pressure to produce more environmentally friendly. The goal is not only for the Company's future success, as well as ensuring the health and well-being of generations to come.

The preceding is a new global idea that emphasizes the interconnection of sustainability's economic, social, and environmental pillars. Profit growth will be propelled by economic sustainability achieved through resource efficiency. Meanwhile, environmental sustainability aims to avert detrimental and irreversible environmental consequences by judiciously utilizing natural resources. Lastly, social sustainability seeks to address the internal safety and well-being of employees, along with meeting the needs of society. Sustainability is a component of improving the overall efficiency of a company's goods and operations in order to achieve economically, ecologically, and socially viable growth.

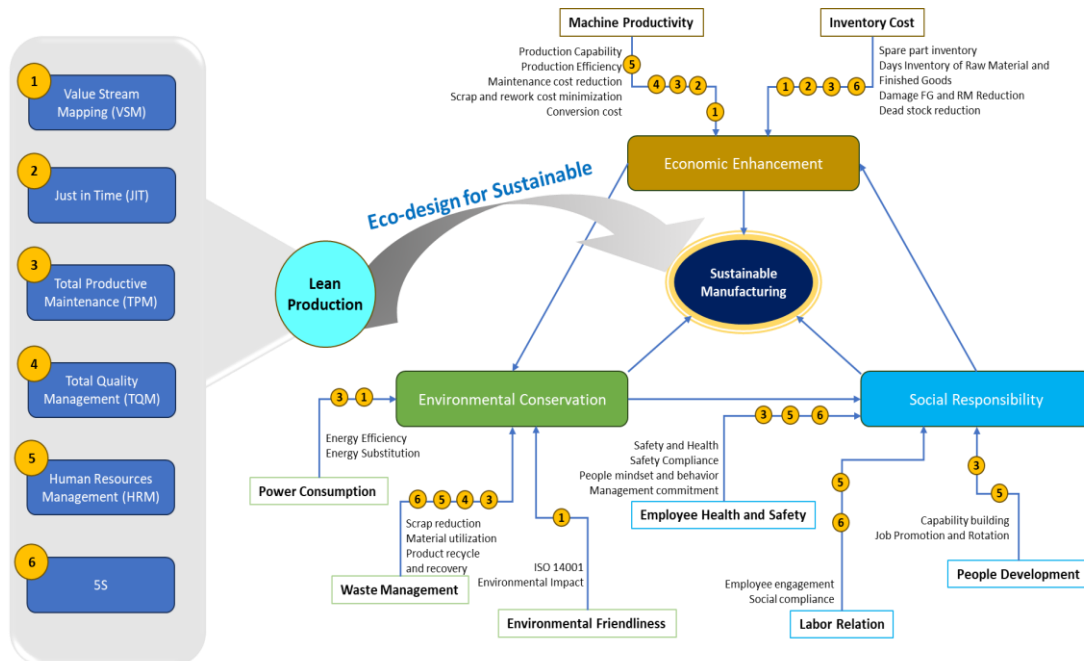


Figure 2. Translating Lean Production Practices to Sustainable Manufacturing

Various Lean Production implementations have been carried out in order to accelerate manufacturing in the FMCG industry. Lean Production, as a lean process and practice, may provide a value that is oriented toward the consumer by identifying various waste. (Nääs et al., 2016). In addition, lean production also focuses on reducing waste of both time and non-value-added resources through continuous improvement to enable smooth product flow. Adherence to standards is also practiced during the manufacturing of a product. In reality, lean manufacturing uses a pull approach to minimize overproduction and eliminate waste by concentrating on demand and producing accordingly, and in its implementation, lean production minimizes waste by optimizing existing resources.

Lean production practices are closely related to manufacturing sustainability through the Triple Bottom Line approach, which can be clearly illustrated in Figure 2.

Value Stream Mapping (VSM). It is a Lean production tool that can be used to design, analyse, and map the entire process flow both value-added and non-value-added by examining the flow of raw materials from its suppliers to the end consumer. By

evaluating the entire process flow, the Company can increase the economic value of a product, increase employee satisfaction due to shorter waiting times, and also by reducing the waste generated in a process, it can reduce the burden on the environment. The company can evaluate the environmental burden during the product life cycle process. The machining process is the largest contributor to a manufacturing process because of the significant increase in carbon emissions. By optimizing the process, it is expected that there will be an increase in asset utilisation so as to reduce carbon emissions and environmental burden due to increased waste generation. Furthermore, the deployment of VSM allows firms to minimize lead times and production timelines, simplify manufacturing, and increase product quality. This can cut operational expenses, increase flexibility and assist the company in meeting customer demands.

Just in Time (JIT). An organization must produce the correct product at the appropriate time. With the implementation of JIT, the company will achieve success with reduced production costs, reduced inventory, and turnover time. JIT not only focuses on the amount needed but actually at the time consumers need and not created in a state of surplus or before the need. By implementing JIT, from an economic perspective, the Company can control inventory costs with a minimum amount of inventory to meet consumer demand so that inventory turnover can be increased. The application of JIT can also increase machine productivity due to the reduction in product setup costs which include labour costs, increased energy used, raw material costs, and costs due to rejected products due to the setup process. In addition, through the application of JIT, simplified purchasing can be evaluated while ensuring a stable supply flow and keeping inventory costs low. Thus, it can limit the number of products on hand and limit the risk of dead stock and backordered products. Ultimately, JIT has a high impact on quality, speed, dependability, and cost.

Total Productive Maintenance (TPM). TPM implementation combines equipment operation and continuous maintenance. Employees with certain credentials or competencies are in charge of constantly monitoring and maintaining equipment in excellent working order. Implementing TPM may decrease losses related with maintenance, downtime, and failures while also ensuring optimal efficiency throughout the equipment's lifecycle. This increase in technical efficiency positively drives the growth of manufacturing companies so as to improve organizational performance. Another important thing is that with the implementation of TPM, it can reduce employee stress levels due to decreased productivity which can lead to high accident rates, decreased employee health, and decreased employee satisfaction levels.

Total Quality Management (TQM). The application of TQM aims to improve quality so as to reduce the cost of low quality. By improving quality through system and process improvements, machine productivity will increase and the defect rate will decrease. This decrease in product defects is a decrease in waste that can reduce waste handling costs. The implementation of TQM can also increase consumer satisfaction with the products produced because the products are of higher quality and have low variability so that there is uniformity of product quality in the market. In addition, with the implementation of TQM, it can reduce risks to workers and increase satisfaction with workers.

Human Resources Management (HRM). HRM as a strategic and comprehensive approach to managing resources (workforce) and managing the work environment in the company. This system will effectively maximize each individual so that common goals can be achieved by fostering human resources. In practice, human resource sustainability starts from the selection and recruitment process, training and career development, and performance review or assessment and rewards. Employees are very valuable assets that need to be maintained by the company. Through increased knowledge, changes in mindset and behaviour, it strongly encourages all Lean practices so that it can encourage the creation of sustainable manufacturing. Top management commitment is very important in implementing HRM because if it is not done, consistency does not work.

This causes a high capability gap between employees which can reduce overall performance.

5S. 5S is a management methodology that can assist us in efficiently organizing work and work areas. With the use of the 5S (Sort, Set in Order, Shine, Standardize, and Sustain) principles. It may assist decrease waste, increase quality, and maximize production if done correctly. In practice, 5S may result in a clean work environment that helps employees feel secure and comfortable at work, lowering the risk of workplace accidents and improving employee health. This can also boost employee loyalty to the organization.

The use of lean production in the manufacturing business improves environmental conservation by identifying and assessing the full product life cycle using Value Stream Mapping to decrease key losses in the industry. Monitoring and regulating system availability and equipment performance promotes production sustainability by increasing energy efficiency and extending equipment life cycles. This may be accomplished by reducing breakdowns, tuning and adjustments, small stops, and loss of speed. Unpredictable and uncontrolled breakdowns are frequently the source of safety and environmental problems, which may be addressed by using TPM and TQM. By overcoming losses due to defects, manufacturers benefit in terms of increased output, safety, environmental health, final product quality, customer service, and competitiveness with competitors.

Monitoring and controlling availability through JIT implementation may also enhance economic and environmental performance since increased inventory of raw materials/finished products raises purchasing and storage expenses. The corporation must be able to foresee and know the amount and time required by consumers in order to avoid creating surplus stock.

5S is the basic foundation for the implementation of JIT, TPM and TQM. Without a good implementation of 5S, the three lean production practices do not run optimally. HRM is the basic foundation of other lean production implementations. HRM is very important because it is directly related to human resources that need to be formed and developed through the formation of discipline, changes in mindset and behaviour and increased opportunities to learn and grow. Increased resource capability will strengthen decision-making in various business strategies in manufacturing sustainability.

In the integration from lean production to sustainable manufacturing, mediation is needed as a catalyst for change. The mediation indicator is eco-design for sustainability. Eco-design is an approach that integrates the environment into the design of products and services so as decrease the influence on the environment by considering the entire product life cycle. Eco-design is very important starting from planning, process, and product. In design planning, companies must consider all aspects of environmental impact from the choice of raw resources to be used, the production process, and the lead time of a product cycle. Not only that, transforming materials into products is also a very complex part of manufacturing. Process design is also very important in planning the stages of the process that must be passed to make products that have the least environmental impact while maintaining the productivity of a piece of equipment. Continuous process improvement can increase the productivity of equipment and prevent high waste due to process mismatches or product defects. Product design considers how and to what extent the product can be used. The adoption of TQM from a quality standpoint, including participation in the selection of appropriate materials and production methods, may improve product durability and decrease waste. In terms of functionality and efficiency, items that are convenient and effective are less likely to be replaced by competitors. In the product's end-of-life cycle, it is vital to consider how to recycle the product and packaging, as well as how to educate customers on how to dispose of and use the finished product. Eco-design not only improves environmental results but may also lower long-term expenses.

Therefore, lean production practices can help Company X to deliver products and services faster and cheaper through inventory reduction. Lean production is a continuous process that if executed well and effectively will become sustainable manufacturing by considering the entire product life cycle in the industrial process.

8. Limitations of The Study

The limitations of the research were that

1. The research results are limited to manufacturing company X which is an FMCG company.
2. The company implements lean practices that are used to drive the sustainable manufacturing
3. Future state map development will not be included in this study
4. This research does not explain how to implement lean production
5. This research only explains the relationship between lean production implementation and sustainable manufacturing through mediation indicators with the conceptual model.

9. Conclusions

Lean production is critical to the development of sustainable manufacturing. The use of VSM, JIT, TPM, TQM, HRS, and 6S is the means to construct a strong and sustainable future in terms of economics, the environment, and socials. The introduction of lean manufacturing in the FMCG sector at Company X improves environmental conservation through the use of VSM, which aids in analysing the complete product life cycle by evaluating the value that can and cannot produce additional value. Inventory control becomes critical as the foundation of JIT implementation. This is strongly tied to initiatives to create economically sustainable manufacturing. The implementation of TPM and TQM can enhance the productivity of equipment or machinery. This helps to decrease costs caused by equipment downtime, increased waste, and worker hazards. Both methods are directly tied to manufacturing that is economically, ecologically, and socially sustainable. On the other hand, using 6S as part of a lean implementation effort in sustainable manufacturing may boost workplace safety and comfort, as well as employee satisfaction. Meanwhile, human resource management (HRM) is the fundamental cornerstone of human development because of management's dedication to strengthening human resources via training and career promotion. This research is different from previous research in that this research translates lean production practices in encouraging the creation of sustainable manufacturing which is described in the conceptual model framework of the relationship between the two. Eco-design is described as a mediating indicator in the creation of sustainable manufacturing in the FMCG industry. The design required in the sustainability process begins with planning, then moves on to process and product. To reduce the environmental effect of a product, its full life cycle must be analysed before it is produced. Eco-design not only improves environmental outcomes but may also lower our long-term costs. This is because lean production practices can reduce operating costs and enhance manufacturing performance through continuous improvement in eliminating waste and creating high-quality and environmentally friendly products so as to increase customer satisfaction.

This research is limited to the companies studied and does not adequately represent the FMCG industry in Indonesia, so future researchers can replicate the research with a larger sample of different types of FMCG industries in Indonesia. In addition, this research is only limited to 6 lean production practices against 8 manufacturing sustainability

indicators. Future research can be extended with other manufacturing sustainability indicators such as technology improvement, digitalisation utilisation, and innovation of product and process. Nevertheless, the conceptual model generated in this study provides an overview and insight into how lean production practices can be used as a driver for achieving manufacturing sustainability in the FMCG industry in Indonesia.

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