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Implementing Lean and Green Principles in the Nigerian Oil and Chemical Manufacturing Sector

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Abstract

The study focuses on how Lean and Green ideas are applied in oil-producing facilities, especially in Nigeria The study assesses the manufacturing operations, difficulties, and opportunities for improvement for businesses such as the Nigeria Oil and Chemical company through quantitative data gathering through email surveys and qualitative review of prior studies. The company's average daily production, equipment capacity, and employee engagement are among the key findings. There are suggestions for sustainable waste management, including putting in place efficient maintenance procedures and marketing byproducts. To improve performance, tactics like employee training, better equipment maintenance, and inventory supply system optimization are advised. The study highlights the importance of introducing backpropagation optimization for establishing monthly targets and advocates for the adoption of Lean and Green concepts alongside tools like 5S (Sort, Set in Order, Shine, Standardise, and Sustain), root cause analysis RCA, and Value Stream Mapping to enhance production output, reduce waste, and cut costs.

1. Introduction

The majority of businesses are designed to turn in profit. As a result, producers and suppliers are responsible for meeting consumer expectations about product quality, quantity, and delivery time. Therefore, it is most likely that manufacturing benefits from the opportunity to grow its client base as long as consumers' interests are met, which leads to a large profit margin. But there is a strong component known as "wastes" that works against maximizing the profit of any manufacturer. In any firm, there are a lot of instances of waste. Production processes, for instance, typically entail labor-intensive tasks, material handling, transit (movement), operation of machines, etc. in manufacturing organizations.

There is a method for each of these elements to promote waste, some arise from wasteful spending, some from production delays, and some from subpar or defaulted goods. In general, waste is any additional expense incurred during the production process that does not provide value to the

company and should be discouraged to support the viability of the enterprise. To maximize profit in manufacturing enterprises, it is imperative to promote an efficient manufacturing process by eliminating waste. Thus, the notion of Lean and Green (L & G) production is a well-established and standardized way to get rid of waste and make sure the manufacturing process is sustainable. "Lean and green manufacturing" is a concept of waste elimination implemented in the industrial industry.

Lean manufacturing, as defined by [1], focuses on avoiding waste in the production process to reduce unnecessary expenditures. The ideas of lean and green manufacturing centres on creating a strong manufacturing process by getting rid of waste in the process of producing goods. Lean advocates for identifying and addressing the unpredictable and illogical manufacturing processes that ultimately lead to waste. At this point, it is possible to discuss the long-term activities involved in maintaining a healthy production process [2]. As a result, this study looks at Nigeria's chemical and oil industries' manufacturing operations. The difficulties of conducting a healthy manufacturing process are also examined, and the idea of lean and green manufacturing is shown to be the answer. As a result, the L&G concept is researched to determine how successfully its benefits can be proven.

Numerous factors in production can result in waste and inefficiencies, which eventually impair productivity and profitability. Resources are wasted when production is started too soon or produced in excess without taking demand into account. Production delays can be attributed to several reasons, such as the availability of raw materials or malfunctioning machinery, which impedes timely delivery to clients and may result in a decline in market share. Despite being essential, transportation might result in unneeded expenses if it is not streamlined. Subpar products and non-value-added activities can result from poorly designed items or processes. Effective inventory control is essential to prevent excess inventory, which can lower profitability. Finally, ineffective performance can drastically reduce process efficiency. This is frequently the result of overusing resources. Manufacturers need to implement standardized and flexible procedures, closely monitor inventory, and maximize production operations to survive in a competitive market. Lean has found numerous inefficiencies in the production process, which are considered waste in the business world because they do not contribute value. An operating system that optimizes value-added, minimizes necessary assistance, and gets rid of waste in every step of the value stream is known as lean manufacturing [3]. The lean idea focuses on strategies to increase profit by removing waste and maintaining customer respect. Furthermore, lean emphasizes the removal of waste to create a productive and sustainable production process. Thus, Waste Elimination, Flow, Pull, Organizational, and Sustainability are the fundamental lean techniques for maintaining healthy manufacturing processing. Lean manufacturing focuses mostly on streamlining the production process by getting rid of waste. Of course, waste comes in many different forms, as Lean lists. It is evident that, in the framework of the Lean concept, a specific type of waste cannot be removed, such as when extracting fluid from sugar cane. The extract is used in the following stage of production since it is regarded as a valuable item. The leftovers are disposed of as waste (natural waste; linear economy promoted). Thus, it makes sense to classify the final output of a production process as valuable goods and natural wastes, either continuously or on occasion.

The valuable products are treated well for customer use and are considered a pleasant by-product, whereas the aforementioned trash is often disposed of [4]. Recyclable products, minimal levels of hazardous emissions, energy and water efficiency, and durable, biodegradable, renewable, and reused products are some of the characteristics of green products. Manufacturing companies worldwide frequently struggle to grow their businesses by maximizing profits while satisfying customers. Nonetheless, engaging in any kind of imprudent behavior ought to be avoided. These actions, however, only permit the addition of cost to the product—not value. In Nigeria, waste is a problem in the manufacture of chemicals and oil. Waste is one of the major problems with

conventional production methods, among many other issues. Both the quantity and quality of manufacturing output have been impacted by this.

To reduce waste in the manufacture of chemicals and oil, the L & G concept was examined to see how best to use it. The production activities of Sudit Oil and Chemicals have advanced from a pragmatic stage to a complex one. Production has traditionally been understood as INPUT—PROCESS—OUTPUT. Yet, there is always an imperative to increase productivity, lower expenses, remove waste, and do much more. Therefore, problems or difficulties facing the current manufacturing system would typically necessitate advancements in the production process. Based on the production record, it was noted that similar to other manufacturing processes, there is daily volatility in production relative to machine capacity throughout the extraction of solvent at Sudit Oil and Chemicals. Additionally, it was noted that as production nears its conclusion each day, the lengthy extraction period lengthens. In addition, given the effect on the environment, the stench during the final hour of daily manufacturing is abhorrent. All of this has raised serious issues that need to be resolved right away. This research aims to investigate the application and impact of lean and green approaches within Nigeria's oil and chemical firms, aiming to ensure a dependable production process. Specifically, the study seeks to analyze how these approaches are implemented and their effects on the operational efficiency and environmental sustainability of the manufacturing processes in these industries.

Outlined within the objectives of this study project are the following key components:

i. Utilizing various tools and methods to potentially optimize manufacturing times, thereby enhancing overall production efficiency.
ii. Conducting an assessment of the waste generated in the solvent extraction plant and evaluating their implications on the production cost and profit margins of the business. This analysis aims to identify areas for waste reduction and cost-saving measures.
iii. Proposing the standardization of production processes to promote consistency and quality throughout operations. Standardization can streamline workflows, minimize errors, and improve overall productivity within the manufacturing facilities.

2. Literature Review

Improving production efficiency has become crucial in the field of manufacturing. This is because manufacturing profit maximization is a productive manufacturing process. Manufacturing must be extremely disciplined by implementing a relevant manufacturing policy to guarantee a healthy manufacturing process [5]. Lean manufacturing is an outstanding illustration of such a tactic. This section covers a variety of writings by many writers that explain lean and green production concepts and their effects on production.

2.1 Production and Lean

To reduce waste and boost productivity in its production processes, Toyota originally developed the lean concept [6]. But the book titled "The Machine That Changed the World" duly described the first group of individuals to study lean manufacturing. With the assistance of government organizations and financial organizations in these areas, the writers of this book conducted an in-depth study in cooperation with other automakers from the United States, Japan, and Europe. How the Toyota production system functions was the subject of research undertaken by Emiliani [7, 8] and Holloway and Hall [9]. The book was based on a Massachusetts Institute of Technology (MIT) study about the future of the automobile, as explained by Toyota's lean production. Thus, following several years (about five years) of research in the Western automobile industry, the results were so

positive that the breakthrough attracted a great deal of attention from many companies across the world. As such, the research on lean was carried out, leading to the recording of the subsequent improvement actions.

i. First and foremost, it is necessary to determine how to transition from the antiquated mass production pattern to the cutting-edge manufacturing method, which is lean.
ii. The previous item (i) contributes to the lean concept's widespread acceptability and makes room for a deeper understanding of lean manufacturing. A significant improvement was seen in the manufacturing activities, which improved long-term sustainability and growth due to the development of the client base and profit maximization.
iii. Other businesses worldwide, outside the manufacturing sector, have embraced the lean concept as a result of the manufacturer's success in implementing lean technology. These businesses have achieved tremendous success and long-term sustainability and growth through healthy business practices that have assisted in cost reduction through the elimination of waste. This has contributed to the lean concept's continued dissemination [6].

As a result, lean manufacturing is now widely accepted in both large and small industrial organizations worldwide. Furthermore, specific lean tools and practices need to be used to fully benefit from the lean idea, according to Masuti & Dabade [10] Just-in-time (JIT), total preventative maintenance (TPM), continuous improvement—also known as "KAIZEN"—standardize quality management, and pull production are a few of these. Nonetheless, Lean acknowledges the existence of an enhanced conventional production system (also known as the mass production system in the context of Toyota production), which needs to be investigated to improve performance even further through the application of the Lean concept not only in Toyota production but in all businesses worldwide. The term "mass production philosophy" was first used by Henry Ford to refer to large-scale production that produced uniform goods with little variation. The mass production system, which was implemented and documented in the US and Europe, and the lean production method, which was documented in Japan, were thus vividly compared within the automotive industry by "the machine that changes the word." Therefore, the lean system and mass manufacturing are contrasted.

2.2 Manufacturing and Green Concepts

Business owners frequently confront a variety of environmental protection difficulties in their quest to please clients [12]. The green notion, as defined by Panjeh and Hamid [11], is a tactic for promoting sustainable development by adopting a circular economy. According to Ahn [12], green technology also entails recycling, reusing, and decreasing waste generated during production; yet, there are several views on green marketing: manufacturing of goods that are regarded as safe for consumption.

i) Manufacturing goods to lessen negative environmental effects or improve environmental quality.
ii) Make items and package them in a way that will appeal to environmental consciousness

This indicates that there are several ways in which the application of workable technology might enhance the environmental outcomes of manufacturing production operations. According to Porter and Van der Linde [14], healthy manufacturing processes frequently use less energy and water, less expensive raw materials, and reduced expenditures for occupational and environmental safety, among many other things. Therefore, employing fewer raw materials with comparatively less environmental impact is what is meant by "green manufacturing" in the manufacturing sector.
The entire procedure is what green manufacturing is all about. Technology can be used by industrial facilities to improve the environmental results of their manufacturing processes. Recycling garbage

would replace the need to purchase new resources. Additionally, according to Porter and Van der Linde [13], the green idea reduces the cost of raw materials, energy consumption, expenses related to environmental safety, and the environmental impact of manufacturing activities on humans. Therefore, there is much potential for manufacturing to reduce costs and meet environmental demands through green manufacturing.

2.3 Benefit of the Green Concept in Manufacturing

Embracing the idea of green manufacturing has greatly benefited companies, clients, and the public at large. Kanchan et al. [14] assert that green marketing creates space for increased competition, which benefits manufacturing practitioners by enabling them to more successfully compete with others in their industry. Still, the advantages of green marketing are as follows [15].

Green image: This refers to the creation and marketing of goods and services that are friendly to the environment. In the end, this makes the company stand out from other manufacturing sectors and raises environmental awareness in the community.

Provide room for expansion: Creating new jobs and expanding the economy are two benefits of embracing the green idea. Green marketing allows organizations to reach a wider audience of potential customers. Green practices help to maintain valuable natural resources, which in turn promotes environmental development.

Significant reduction in environmental Risk: Pollution frequently results in environmental dangers because of poor manufacturing methods. When dangerous substances are released into the environment, it results in pollution. We refer to these toxic materials as pollutants. Air, water, and soil quality are frequently contaminated by these pollutants, which can be introduced naturally (e.g., ash from volcanic eruptions) or artificially (e.g., trash or runoff created by manufacturing sectors). As a result, adopting the green marketing idea improves the environment by getting rid of or cutting down on water and air pollution as well as other risks that people face daily.

Potential for entry into the market: Businesses that produce environmentally friendly goods or services are considered green-inclined and have a big chance to enter the market and make more money. Consequently, the implementation of green marketing strategies in manufacturing yields benefits such as enhanced product differentiation and the ability to penetrate emerging markets and consumer segments. As a result, integrating green technology for production into the manufacturing process is a significant idea that elevates companies from a surface level to a higher plane. However, Seth et al. [16] identified five key areas into which the possibilities of enacting green manufacturing strategies can be broken down: product change, production process adjustments, altering intake in the manufacturing process, internal waste reuse, and improved housekeeping.

2.4 The Five Principles of Lean and Green

For the past few decades, lean and green methods have produced high-quality goods and business success. In this instance, lean and green concepts are widely regarded as cutting-edge methodologies and the most significant manufacturing paradigms in developed economies across the globe. Furthermore, Womack and Jones [17] identified five (5) fundamental principles of lean and green manufacturing [18].

Value Establishment

Examine your product thoroughly and ask yourself, "What value does the item in question provide? And to whom?" Additionally, reevaluate your product from the standpoint of the final user. What benefits does this product offer? What makes the product so special [19]?

Value Stream Identification

Once the worth of the product has been established, consider what is needed to produce your final product. What are the various stages in the procedure, for instance, that I should follow? Value stream is one of the most important tools in a lean practitioner's toolbox, therefore it will take a lot of time, but it will be worthwhile [19].

Flow Achievement Through the Process

Analysis of every phase or path of your product begins with a successful identification of the value stream. Work your lean tools, particularly the stages of the evaluation by putting them to work in real-world scenarios. Next, begin evaluating what can be simplified, what is truly necessary to reach the final goal, and what is a waste of time, money, and resources [19].

Kanban or Pacing by a Pull Signal

This entails knowing the demands of the customer and applying strategic thought and timing. Pulling signals is also related to meeting demand. Additionally, by understanding when your customers require your goods, you may adjust production schedules to meet their needs [19].

The Continuous Perfection Pursuit

Lean production is centered on ongoing development and improvement. There is always room for improvement, no matter how flawless and effective your methods are; "if you would like to get leaner," you must constantly be prepared to start over. Return to the process mapping, value establishment, and improvement identification phases [19].

Inter-Relationship of Lean-To-Green

Merging lean and green practices is similar to synergistically merging environmental management and operations. To maximize the enormous benefit of the connection, each partner must have a favorable influence on the other. For instance, synergy is commonly explained by the equation 1+1=3, which says that adding separate performances does not produce as stunning results as combining activities. Therefore, for lean and green practices to complement one another and perform well, lean must progress and enhance green practices. Combining lean and green approaches can help them realize their full potential and provide a lot more benefits than either approach alone. This could be defined as where environmental activities can enhance lean practices, lean processes can likewise improve environmental practices [20].

The idea that, when implemented, lean aims to reduce non-value-added operations, which in either a direct or indirect way helps drive down the negative consequences of the generation of less waste, is the basis for the relationship between lean and green practices. The fact that Lean can strengthen the benefits of pollution eradication strategies is one of the key details of their relationship. The Environmental Protection Agency (EPA) claims that there are connections or inherent environmental waste within the seven lean wastes. Therefore, when lean techniques are applied to a specific pollution prevention activity, environmental waste can be viewed as the eighth kind of waste, which is how green manufacturing initiatives can maximize their profits. Since both strategies attempt to save costs while increasing efficiency and achieving better results in terms of time, quality, and value, they both intend to improve performance metrics. Green production techniques lower material waste and energy usage, which lowers production costs and speeds up production. Additionally, it improves the quality of the production process, which affects the quality of the final product [21].

3.Nigerian Practices of Lean and Green Concepts and Their Difficulties

One of the emerging nations where innovation and progress are embraced slowly is Nigeria. This is a practice that has an impact on numerous developing businesses. However, there are several possible causes for this. However, for the success of the industry and the community as a whole, there is always a need to inform and educate the general public about the need to embrace any revolutionary idea. Thus, green manufacturing is a new paradigm designed to give manufacturing businesses a balanced system in their production processes, just like any other advancement.

As a result, to ensure a brighter future, manufacturing and consumers alike must be informed about the environmental issues that Nigerian manufacturing faces and how urgently these issues must be

resolved [22]. Kotler [23] asserts that it is possible to deceive customers into thinking that green product advertisements are merely clever marketing ploys. In the end, this can hurt the products' sales. Green concepts and marketing, environmental sustainability, green power and energy, and green products and services all require significant investment in research and development programs, which could lead to higher costs. According to Osuagwu [24], the goal of green marketing is to inform customers. However, there is a great need to inform customers about the potential threats to the environment; if green products are more expensive than other optional items, the company may have trouble finding a buyer. This might cause bias in the field of green marketing. Put differently, green marketing typically meets two main objectives: improving the environment and raising consumer satisfaction.

Green marketing myopia is the state in which a great deal of organizations' short-term resource investment has negative consequences for the latter since none of the parties (stakeholders) are working together to consider the long-term benefits of green products. The latter goals may suffer from poor judgment on either or from concentrating on the former. If green marketing did not encourage or result in cost-cutting (savings), the manufacturing sector would not be interested. This approach would undoubtedly help any organization grow, as demonstrated by research on the effects of lean and green manufacturing techniques. Thus, this study looks into the problems, prospects, and production activities of the company (Oil and Chemical Industry) that is the subject of the study.

a. Brief History of the Oil Palm and Chemical Industry in Nigeria

The palm tree, which is well-known throughout African nations for its several uses, yields the palm kernel, an essential ingredient in the creation of palm kernel oil (PKO). The palm tree produces a variety of goods, such as palm oil, palm kernel oil, sauces, soap ingredients, palm wine, and even building and musical instrument materials. Due to the substantial socioeconomic and environmental effects of this abundant resource base, many African countries—Nigeria in particular—have invested in industrial oil palm farms. Given the historical background, it is evident that palm kernels and palm oil have long been profitable commodities, drawing trade interest from industrialized countries, particularly those that colonized Africa, particularly European powers.

Nigeria presents ideal circumstances for agricultural activity, especially oil palm agriculture, with its large arable land area of 71.2 million hectares. The climate and soil properties of the nation are ideal for the cultivation of tropical and subtropical crops, with oil palm serving as the mainstay of its agricultural economy. Oil palm is mostly grown geographically along Nigeria's riverine and coastal regions, where it benefits from the rich soil and easy access to water for transportation and irrigation. These elements have helped Nigeria become known as one of the world's top producers of palm kernel oil.

Nigeria's production of palm kernel oil has steadily increased over time, demonstrating the country's dedication to agricultural growth and economic diversification. The nation's yearly production of palm kernel oil, which hit 330 thousand metric tons in 2021, serves as an example of this upward trend. Notwithstanding obstacles such as disparities in supply and demand and variations in production output, Nigeria's palm kernel oil sector perseveres because of strong domestic demand and advantageous market circumstances. The industry's importance goes beyond economic domains to include social and environmental aspects, as it persists in being essential to Nigeria's agricultural terrain and overall socio-economic progress [25].

b. Palm Kernel Production Processes

The main raw material used in the production of palm kernel oil (PKO) is the palm kernel seed, which goes through several processing steps. These include gathering the palm kernel seed, cleaning it, and getting it ready to be crushed so that palm kernel cake (PKC) can be made. After that, PKC is extracted using a solvent in a solvent extractor plant (SEP). Common solvents used in SRG, liquified CO2, and hexane are used for this process. De-oiled cake (DOC) and crude palm kernel

oil (CPKO) are the end products of this procedure. Refined bleaching deodorant (RBDO) and distilled fatty acid (DFA)/palm fatty acid (PFA) are the end products of the CPKO's subsequent refinement in a refinery.

Figure 1: The process of producing oil by local or traditional methods.

One important technique used in the processing of oil-bearing materials, especially for vegetable oils, is solvent extraction. It stands out from other extraction techniques like pressing and rendering, and because of its effectiveness—particularly for oilseeds with lower oil content—pressing has been mainly supplanted by it since the Second World War. Effective oil recovery, low material degradation, and high yield are all guaranteed by solvent extraction. Preparation, extraction, de-solventisation, distillation, and solvent recovery are some of the steps in the process that help separate oil from the raw material efficiently.

Hexane, a solvent that is frequently used in extraction procedures, has several benefits, such as being reasonably priced, stable during the operation, non-corrosive to metal, and simple to remove from residue. Its characteristics make effective oil recovery and extraction possible. Modern extraction processes are economically possible because of the solvent recovery system, which guarantees that over 99.9% of the solvent fed into the extractor is recovered. By bringing the cake's residual oil concentration down to less than 1%, solvent extraction helps produce high-quality oil while maximizing the use of available resources.

Like every manufacturing process, the production of palm kernel oil is not without its difficulties and opportunities for development. Waste generation and increased expenses can result from problems including overproduction, excessive inventory, needless movement of workers and equipment, inadequate quality control, and inefficient transportation. To tackle these obstacles, standard operating procedures must be put in place, together with better design layout, improved quality control methods, and transportation process optimization to minimize waste and match customer needs [26, 27].

4. Methodology

The study evaluated the production operations of Sudit Oil and Chemical manufacturing plants in Nigeria, with particular reference to the Oil and Chemical industry in the advanced arena to justify. In any manufacturing, there are typically quite a few line-up activities. The study only looks at Sudit

Oil and Chemical Company's (Nigeria) palm kernel oil production procedures (using a solvent extractor).

a. **Research Method**

The information gathered from various sources served as the foundation for the study. Descriptive analysis is performed using the information about oil and chemical production obtained from Nigerian oil and chemical firms (via a variety of platforms). However, to gain a thorough understanding of the manufacturing behavior under investigation, a telephone interview was done with the processing company's plant manager, operation manager, maintenance manager, and human resources manager. Following this, an electronic mail survey was used. Furthermore, the company's human resources manager received an email seeking the company's operational production data for the previous year and the data were sent back via email. This study also makes use of data from publications and earlier research projects. Nonetheless, this study examined the ideas of lean and green technology as they applied to Nigeria Oil and Chemicals Manufacturing's manufacturing unit based on the data acquired.

b. **Utilised Lean and Green Techniques**

The goal of all lean and green technologies is to help people maximize resource use, cut waste, and increase efficiency. In the meanwhile, certain lean tools might be better suited for manufacturing than others. The most popular lean and green tools are Focus PDCA, Value Stream Mapping, Kanban, and 5S. Nonetheless, for this project's work, the L&G tools utilized are the 4ME1 model and fishbone analysis. This was applied to assess potential reasons for the solvent extraction plant's low output. Relative performance evaluations are essential for a business to perform to track its success against the benchmark. One way to characterize the lean and green index is as a system for evaluating a company's performance over other businesses. This has made many businesses more competitive. On the other hand, obtaining all the necessary data for the case study company is a challenge that falls under the category of manufacturing issues in developing nations. But to succeed in manufacturing consistently, it's important to pinpoint and thoroughly examine the company aspects that require development. This calls for the adoption of a dependable and successful approach, which in this instance is the Lean and Green Index.

5. Results and Discussion

The trend of the MP piece is shown in Table 1 below, along with the corresponding graph and chart. As the Key Performance Index (KPI) result indicated, it was discovered that Manpower initially lacked experience in managing the production process.

Table 1: The 4M1E Parameter Table.

MONTHS	MP	MC	MT	MY	EV	L and G Index
JAN	0.4112	0.756	0.7547	0.6877	0.7342	0.5534
FEB	0.5433	0.6856	0.7677	0.7245	0.7634	0.6646
MARCH	0.3623	0.6911	0.7707	0.7765	0.8113	0.4976
APRIL	0.3598	0.5767	0.8637	0.6675	0.678	0.6589
MAY	0.588	0.4799	0.873	0.7856	0.6858	0.7778
JUNE	0.5988	0.5145	0.8878	0.6145	0.6013	0.7878
JULY	0.6522	0.558	0.8977	0.7845	0.5989	0.8632

AUGUST	0.7687	0.5923	0.9178	0.9266	0.7877	0.8712
SEPT	0.663	0.8367	0.9256	0.9712	0.4477	0.779
OCT.	0.7566	0.9676	0.9566	0.9899	0.711	0.8679
NOV.	0.8967	0.9785	0.9744	0.9934	0.798	0.8878
DEC.	0.9988	0.986	0.9878	0.9167	0.7134	0.995

Where:

MP – Manpower
MC – Machine
MT – Material
MY – Money
EV – Environment

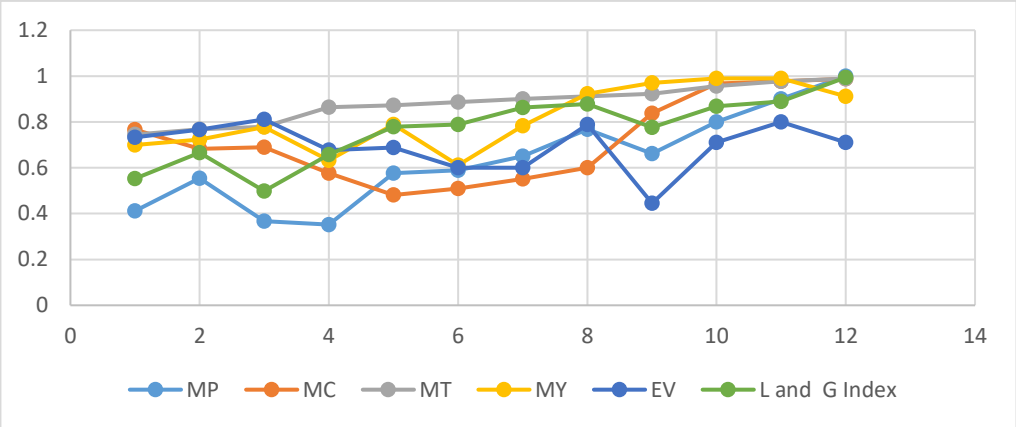

Figure 2: Graph of 4MIE Model Combinations (Chart - 1A).

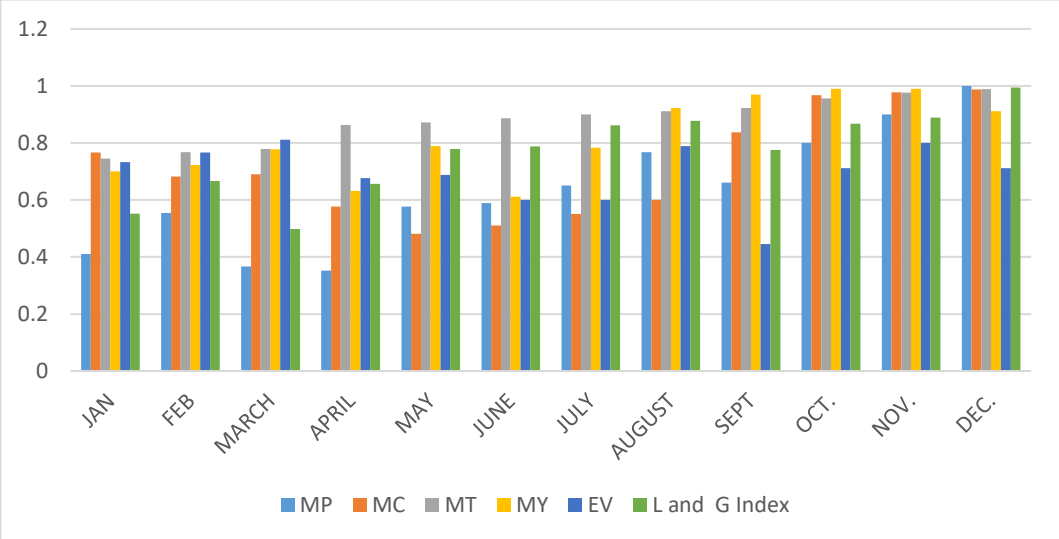

Figure 3**:** Histogram Showing the Combined 4M1E Index (Chart - 1B).

The aforementioned table demonstrates that, except for a few months when MP, MC, and EV were impacted, facilities have operated according to the same schedule for many months. This month's indication plummeted quickly. Meanwhile, as the facility is required to set a monthly target, backpropagation optimisation must be introduced generally. In the meantime, the reflex Manpower index (|MP) is shown in Chart 2. When the MP index was so low in the first several months, it was very depressing. However, in the latter months (May, June, July, and August), the number increased steadily until September, at which point it abruptly decreased. The amount will be collected by year's end. This only demonstrates that the MA's challenge was eventually resolved. However, low MP statistics indicate that the MA's input or touch was not felt in those particular scenarios. There are a few possible reasons for this: Insufficient workforce, leading to decreased output

- Manpower that is accessible lacks the necessary understanding to do the task, which leads to faulty or counterfeit goods.
- Manpower lacks the will to improve their morale, which leads to lethargy and a failure to achieve production standards, quality and quantity requirements, and on-time delivery.

Solution:

- Employers should hire a sufficient number of workers with relevant experience.
- Employees should receive ongoing training to stay up to date with the latest advancements in technology.
- Competitive pay and benefits to encourage employees.

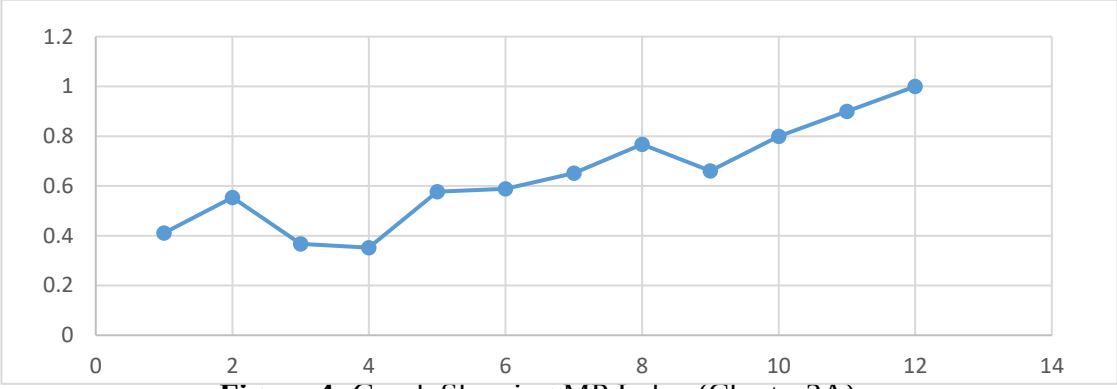

Figure 4: Graph Showing MP Index (Chart - 2A).

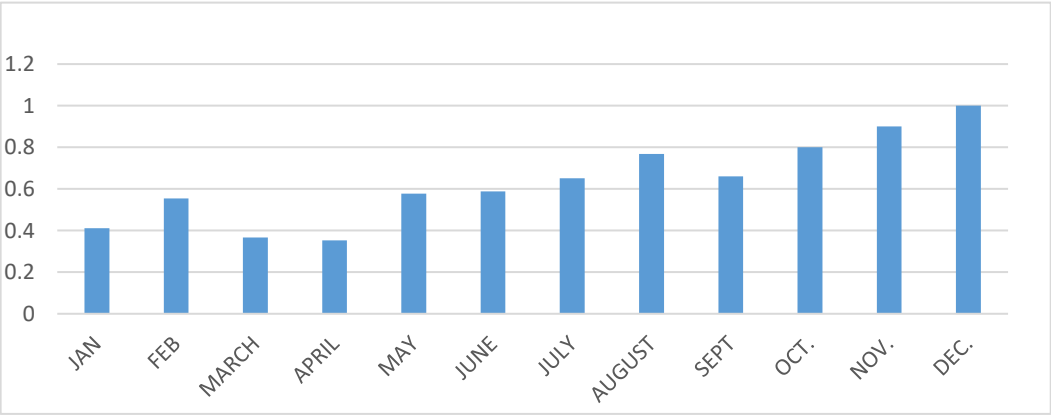

Figure 5: Bar Chart Showing MP Index (Chart - 2B).

Chart 3 - The Machine (MC) is seen in operation below. The machine's maintenance culture efficiency plays a major role in determining the output status (quality, quantity, and timely production). It has been noted that from the start of the year until the end of August, the machine index has been declining. Nonetheless, there is a positive increase in efficiency. Simply said, this indicates that the machine's operating hours were not optimized. This can be the consequence of poor maintenance procedures or a malfunctioning machine. Consequently, given all other factors being equal, the machine's health should be taken into consideration for the overall manufacturing performance.

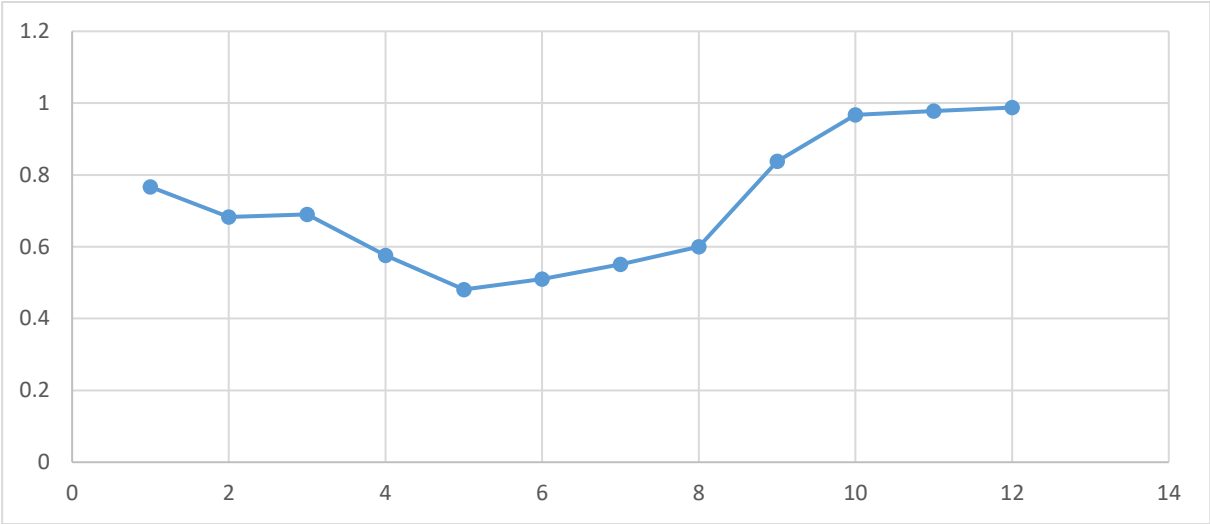

Figure 6: Graph Showing MC Index (Chart - 3A).

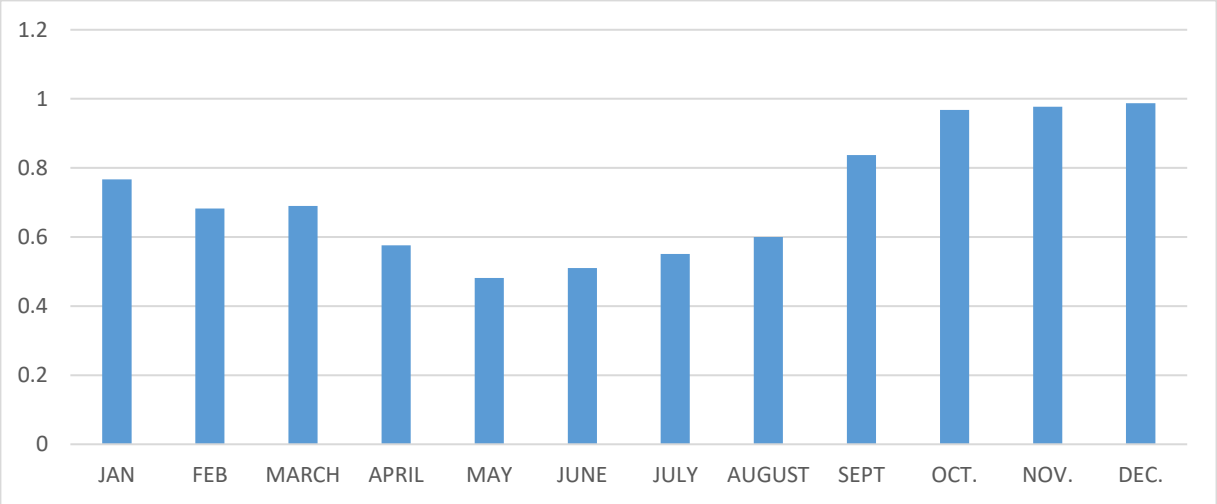

Figure 7**:** Bar chart showing MC index (Chart - 3B).

Chart 4 - This index is called Material (MT). Due to the extremely low demand for PKO during the first four to five months of the year, fewer materials are required for production, which lowers the minimum fuel input required to maintain the idle condition. On the other hand, since there is no need for inventory, there is also no need for storage.

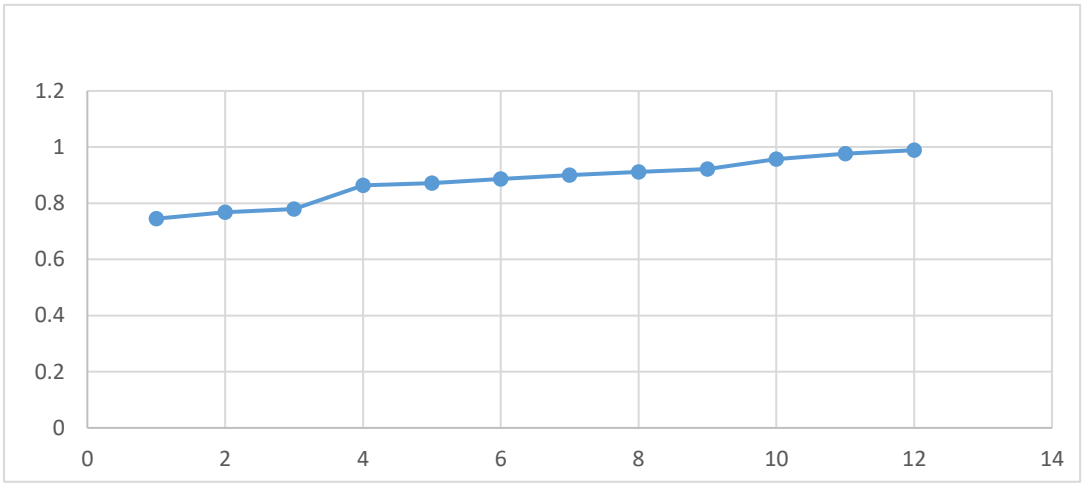

Figure 8: Chart 4A: Graph Showing MT Index (Chart - 4A).

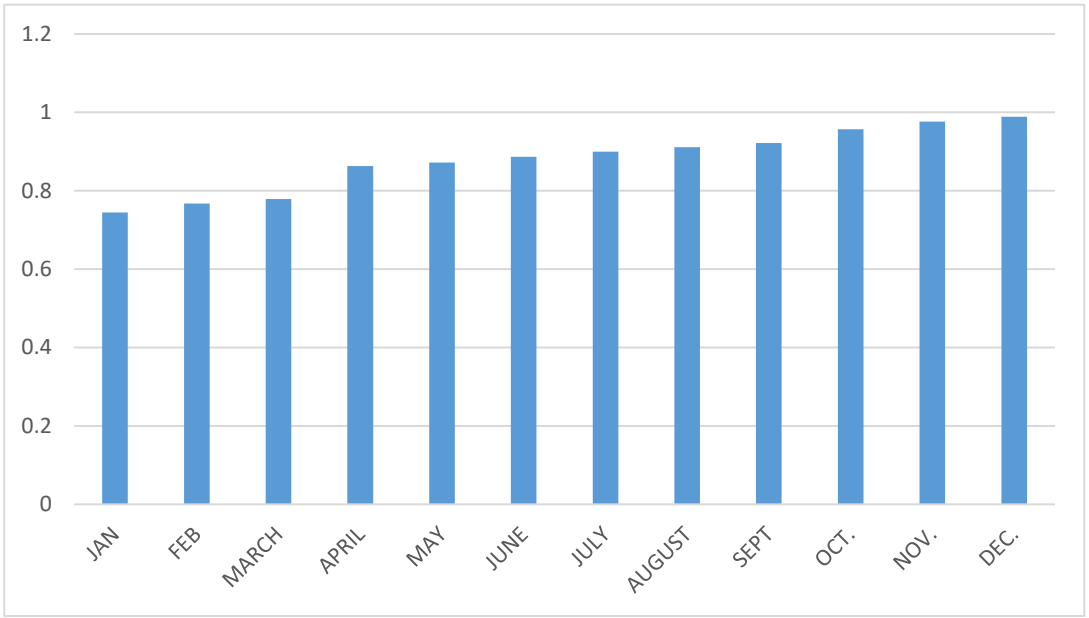

Figure 9: Bar chart showing MT index (Chart - 4B).

Chart 5 - The supremacy factor of money (MY) is seen here, where operating costs are deemed less important than profit indications. For instance, until May and June, there was a significant decline in output, the output through the MY had improved significantly. The required actions were made by the operating team (by investing in the appropriate quarters, such as staff incentives, good maintenance culture, personnel training, etc.). For instance, a qualified contractor has been hired to maintain the system at a predetermined monthly rate. (LGI) is produced as a benchmarking instrument to assess how well a business is performing. As a result, starting in July, the MP index increased quickly.

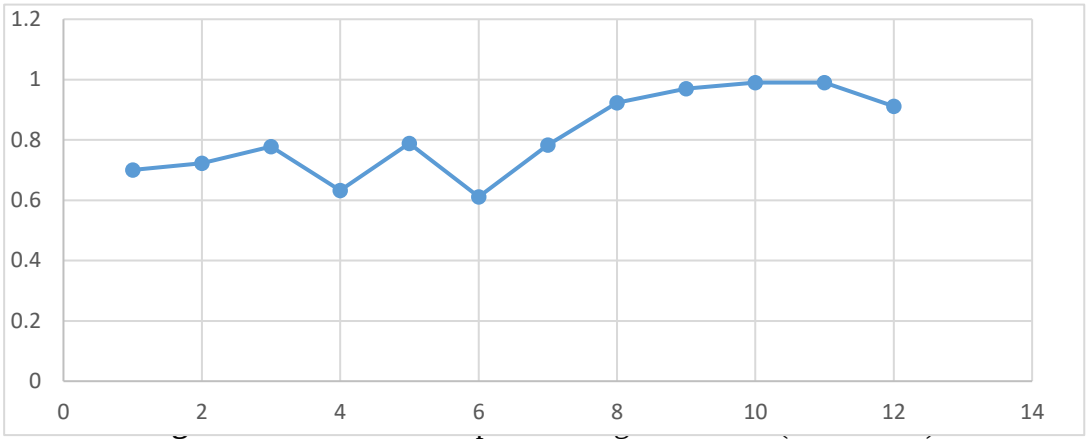

Figure 10: Chart 5A: Graph Showing MY Index (Chart - 5A).

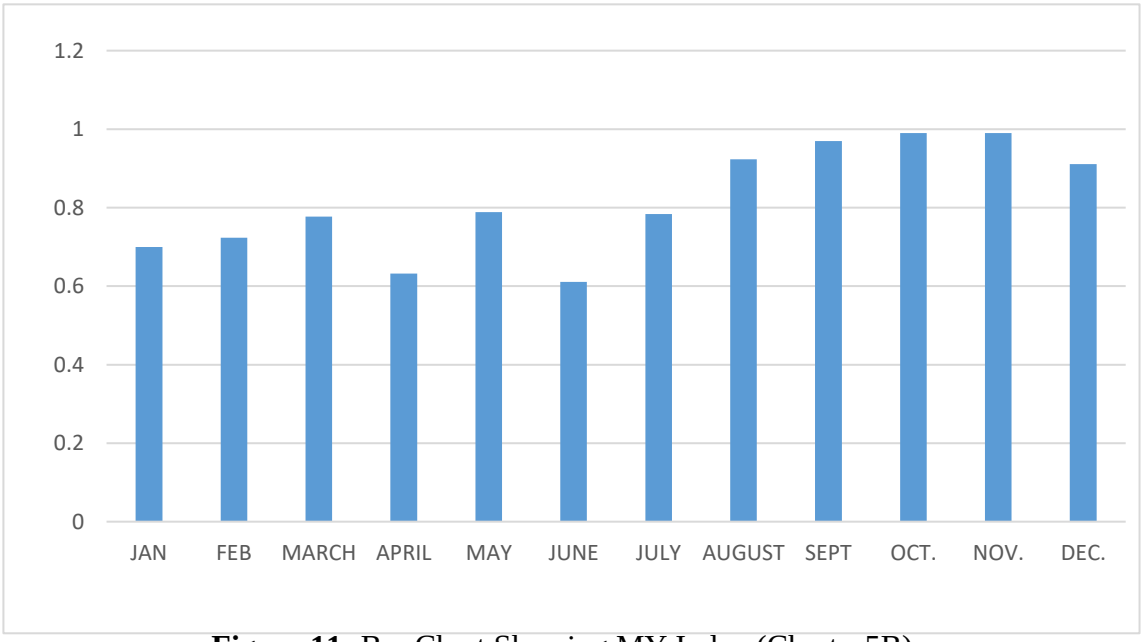

Figure 11: Bar Chart Showing MY Index (Chart - 5B).

Chart 6 - Here is the (EV) The environment index demonstrates that at the start of the year, the index was steady and favorable for output. This steadily decreased, and in August, the eighth month of the year, the number was exceptionally high. The number had gotten so awful by September. Due to the August break in August, not much rainfall was recorded, which was caused by meteorological conditions that discouraged production, such as excessive rains and flooding. By the end of the year, the number soars.

Lastly, even though lean and green methods are highly effective and reliable, they do not guarantee increased productivity. Manufacturing in underdeveloped countries has completely embraced the benefits of lean and green approaches. Nonetheless, manufacturing in poor nations has a bright future provided there is increased awareness and consistent acceptance.

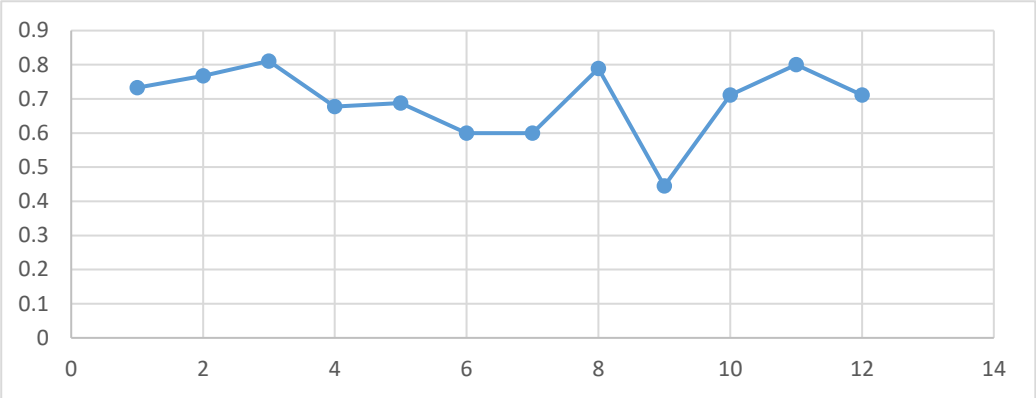

Figure 12: Graph showing the EV index (Chart - 6A).

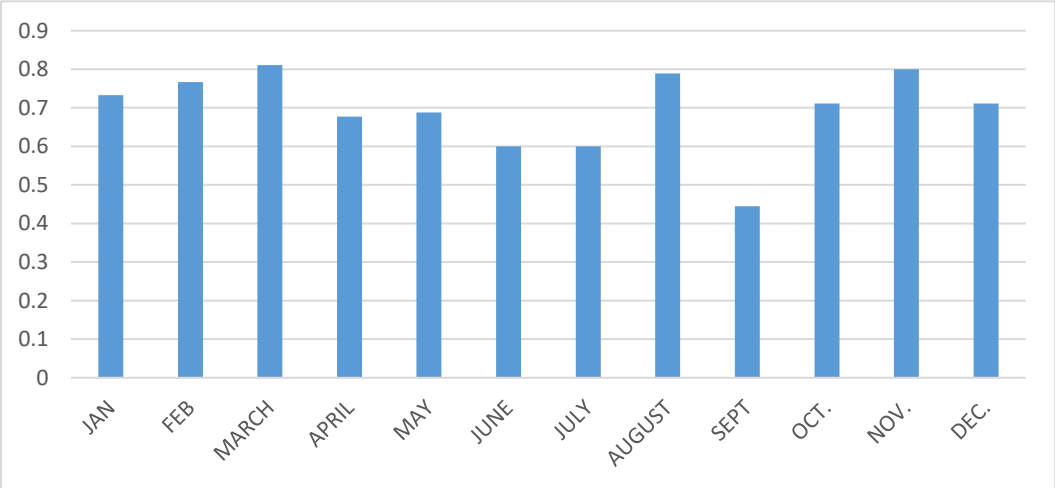

Figure 13: Bar chart Showing EV Index (Chart - 6B).

Chart 7: The (EV) Environment index indicates that at the start of the year, the index was stable and favourable for production. This gradually decreased, and this figure was exceptionally high in August, the eighth month of the year, this figure was exceptionally high. The amount had gotten worse by September. Due to the break in August, not much rainfall was recorded, which was caused by meteorological conditions that hindered production, such as excessive rains and flooding. At the end of the year, the number increases. Lastly, even though lean and green techniques are highly effective and reliable, they do not guarantee increased productivity. Manufacturing in underdeveloped countries has completely embraced the benefits of lean and green techniques. However, manufacturing in developing countries has an exciting prospect provided there is increased awareness and consistent acceptance.

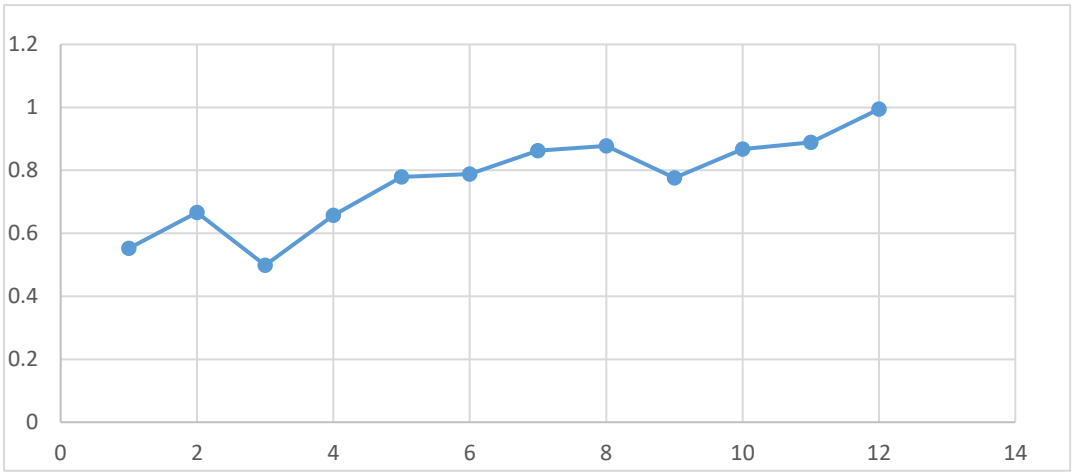

Figure 14: Graph for L&G Index (Chart - 7A).

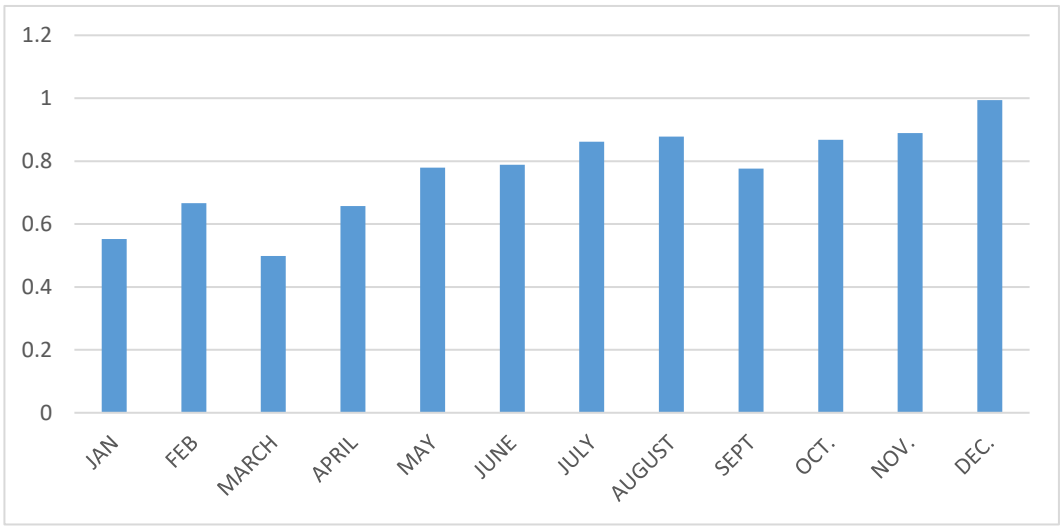

Figure 15: Bar Chart For L&G Index (Chart -7B).

5. Conclusion And Recommendation

4.1 Conclusion

To address operations and environmental waste, combining Lean and Green techniques can assist produce the most sustainable outcome in production. Waste in all forms of industry has led to a great deal of animosity. Since it opposes advancement, it is guaranteeing the liberation of business. It is one thing to recognize waste as a hindrance to business advancement, but it is quite another to comprehend the means of eliminating it. As a result, companies have suffered greatly. They failed despite their goal of maximizing profit. Manufacturing companies must implement business-boosting tactics to grow and compete in the global market. For instance, it was found that PKO's production processes are plagued by numerous problems that prevent the company from getting favorable results, which prevents the business from growing as planned. For SMEs to successfully adopt Lean and Green Culture, management must be completely involved. Hence, for Lean and Green to have a meaningful impact on manufacturing, the corporation must first play the following

role. To constantly be relevant (skilled) in the industrial arena, workers must receive ongoing training; otherwise, the industry will take advantage of them.

4.2 Recommendations

Companies that want to grow dramatically or thrive must put the detection and reduction of waste at the top of their priority list. This entails eliminating non-value-added operations to reduce needless expenses. Furthermore, efficient waste management can generate revenue from items that are ostensibly wasted, protecting the environment. Reusing de-oiled PKC, for example, to produce bird feed is an example of the "green concept," which increases profitability while lowering environmental risks. Organizations must adopt fair inventory supply procedures like JIT, enforce tight maintenance standards to reduce machine downtime, and guarantee worker involvement and training to prevent production errors and losses to fully reap the benefits of lean and green principles. Adopting lean and green concepts and using techniques like Value Stream Mapping, RCA, and 5S can greatly improve manufacturing production and organizational performance. Through cost reduction and waste reduction, firms can increase their efficiency and profitability. Prioritizing incentives, worker training, and equitable pay also encourages employee participation and knowledge, protecting manufacturing processes and fostering sustainable growth.

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