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Frameworks for the New Barrier Areas in Optimising the Implementation of Lean -A South African Perspective

John Zvidzayi
Mangosuthu University of Technology
Department of Mechanical Engineering
South Africa
johnz@mut.ac.za

Abstract

The study seeks to develop the frameworks for the new barrier areas to uncover the hidden obstacles and risks of implementing Lean manufacturing. Ten generic barrier areas will be enhanced by the seven new areas obtained from interviews, work-study, and observation of processes in the automotive industry in South Africa (SA). The areas are green technologies, profitability, sustainability, marketing, core values, workforce culture, and motivation. The literature has guidelines for Lean implementation but lacks the frameworks and models with procedures for each operational area. The study developed frameworks for each operational area using the needs of various automotive industries in SA to assist in implementing lean. Transparency, team rewards, utilization of talent, and respect for people motivated the workforce. The strategic plan was developed to be used by aspiring candidates for LM adoption.

Keywords
Lean manufacturing, implementation, barriers, and frameworks

1. Introduction
When an organization is implementing lean manufacturing, it is critical to consider the generic barrier areas and challenges that other organizations face during the implementation. The multiple barriers encountered when implementing lean are scattered all over the literature in different quantities In the study of the automotive industry in SA, the focus was on the operational areas where the generic barriers existed and developing new areas to improve the implementation of lean. The researcher considered the impact of ten generic areas and identified seven more areas for use in the ASC in SA.

1.1 The Ten Generic Barrier Areas
Figure 1 shows the ten generic barrier areas that were obtained from various literature.

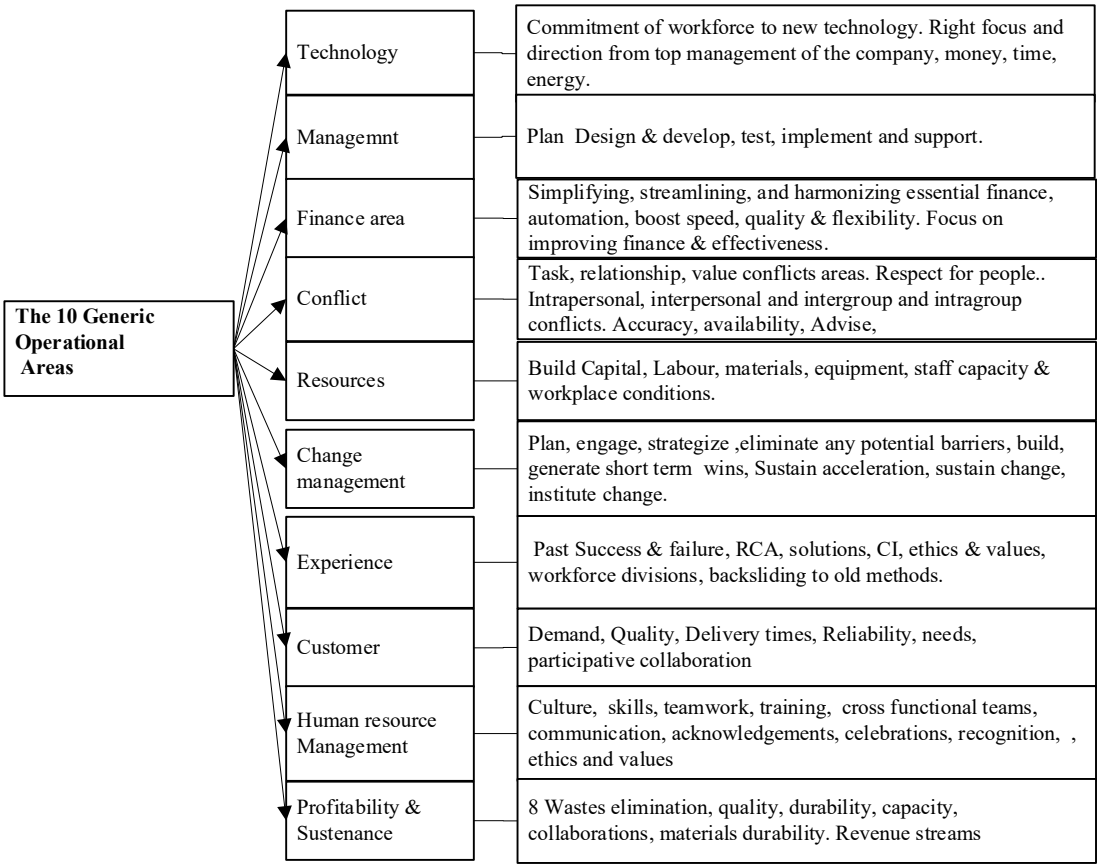

Figure 1. The 10 Generic Barrier areas in Lean implementation (Zhang, Narkhede, & Chaple, 2017)

The success rate when applying these barrier areas is not 100% as evidenced by (Netland, 2016) who listed several success factors in these barrier areas that can be applied to implement lean. Hence the a need to investigate the new barrier areas that are overlooked by organizations when implementing lean.

(Lai, 2020) discussed only three barrier areas whilst (Yadav et al., 2019) uncovered eight barrier areas. Before that (Zhang, Narkhede, & Chaple, 2017) unpacked ten generic barrier areas including the ones by Lai and Yadav. The ten barrier areas are organizational culture, knowledge, management, conflict, resources, technology, finance, employees, customers, and experience (Figure 1).

(Adlina et al., 2020)and (Schulze & Dallasega, 2022) used and validated the application of engineer-to-order (ETO) as an effective method of manufacturing. ETO has barrier areas related to culture, financial, customer, cultural, knowledge, management, and organization-related and nonspecific barrier areas that are just obstacles.

The study seeks to establish sustainable frameworks for the seven new barrier areas in the implementation of Lean to achieve operational, social, economic, and environmental sustainability. An inventory reduction and increases in profit, energy saving, and work routines will be used as evidence of success.

1.2 Methodology

The interviews, discussions, and work-study methods unveiled the seven new barrier areas and their specific barriers to Lean implementation. The interviews and discussions were conducted during the work-study under strict ethical considerations to protect some information about specific customer parts and operations designs.

2. Findings

The new areas have been applied to Lean implementation by the automotive industry in South Africa without knowledge or documented structure. The divergence theory led to the discovery of the seven new barrier areas which enabled the successful implementation of Lean by eliminating hidden barriers on the human aspect. The ten generic barrier areas complied with the convergence theory. The economic, environmental, and social impact of these new areas were critical in the success rate.

The chapter map shown in Figure 2 shows the seven new barrier areas that will be discussed in this chapter.

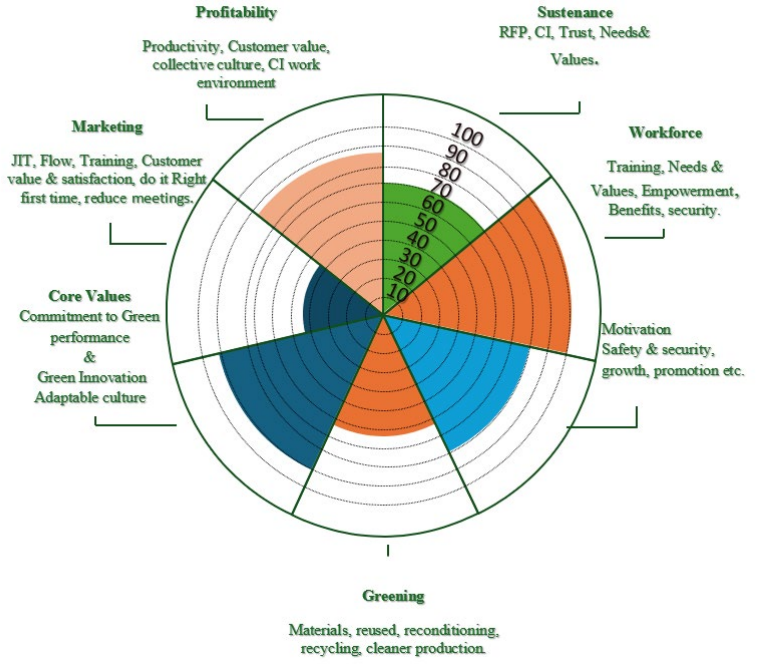

Figure 2. The Seven New Barrier Areas in Lean Implementation (author)

3. The Seven New Barrier Areas

3.1 Profitability

Figure 3 shows the Profitability area framework that can be used to assess and evaluate both short- and long-range economic viability of the business to sustain human resources, equipment, materials, and technological developments. Profitability promotes the social development of the community and allows an improved quality of life in terms of wealth, safety, and well-being (Järvenpää & Lanz, 2019).

The study by (Hasan et al., 2023) identified the interrelationships between lean and sustainable manufacturing and analysis of the performance on the three key dimensions of sustainability which are environment, economy, and social. These areas must create a safe and conducive work environment that meets the customer and employee needs. High productivity will enhance good remunerations, community development, and provision of worker social needs.

In the ASC (Okeke, 2024) recommended the full collaboration of the supply chain to succeed in implementing lean. If the profitability is low, there will be no need to adopt the lean philosophy. Models and frameworks are used to guide the implementation of lean and measure performance.

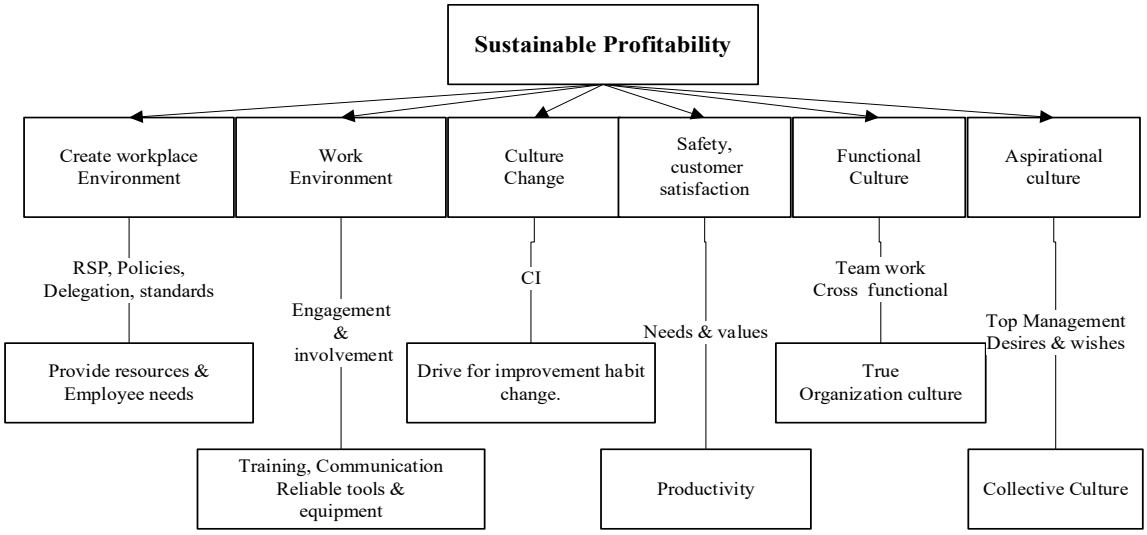

Figure 3. The Profitability Sustainability area (author)

3.2 The Core Values Area

Carvalho Alves et al. (2019) identified five critical attributes of core values. These are mapping the value stream, creating flow, establishing a pull system, striving for continuous improvement, and seeking perfection. It is critical before starting any manufacturing project, to determine the value that a customer expects to pay for it. Lean teams can set the costs low enough by eliminating waste in every process to reach an agreeable price (Figure 4).

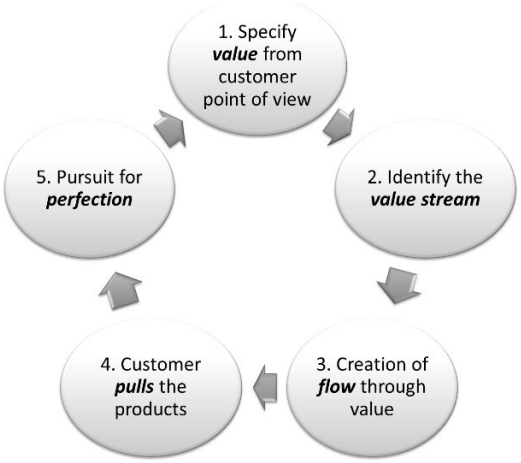

Figure 4. Schematics of the application of Lean principles(Carvalho Alves et al., 2019)

The gathering of the materials needed for production, processing, and shipping to consumers is called Value stream mapping (VSM). Security and safety of the workforce is critical in Lean implementation hence the need to provide PPE and insurances that safeguard the workforce. A manufacturing plant layout that allows materials, equipment, and workforce is important when we consider the ergonomic aspects that aim at comfortable and productive workstations (Ferreira et al., 2018).

(Sayeda Sufia, 2024) concluded that the integration of lean into industrial engineering is transformative in all sectors. It enhances efficiency, productivity, and sustainability by focusing on waste reduction, continuous improvement, and value maximization in the automotive, aerospace, healthcare, electronics, food and beverage, construction, and retail

industries. In the automotive industry, Just-In-Time (JIT) production and Kanban systems minimize inventory costs and improved material flow.

3. 3 The workforce area

Today implementation and practice can be done and controlled with the aid of soft skills that focus on a new mindset that respects customer needs to improve value to the organisation. It is effective in problem-solving and decision-making by collaborating with suppliers, consumers, and users. Communication, adaptability, flexibility, and a continuous growth mindset are the critical soft skills required by each manager (Lima et al., 2023).
Figure 5 shows the framework for the employee deficiencies in lean implementation.

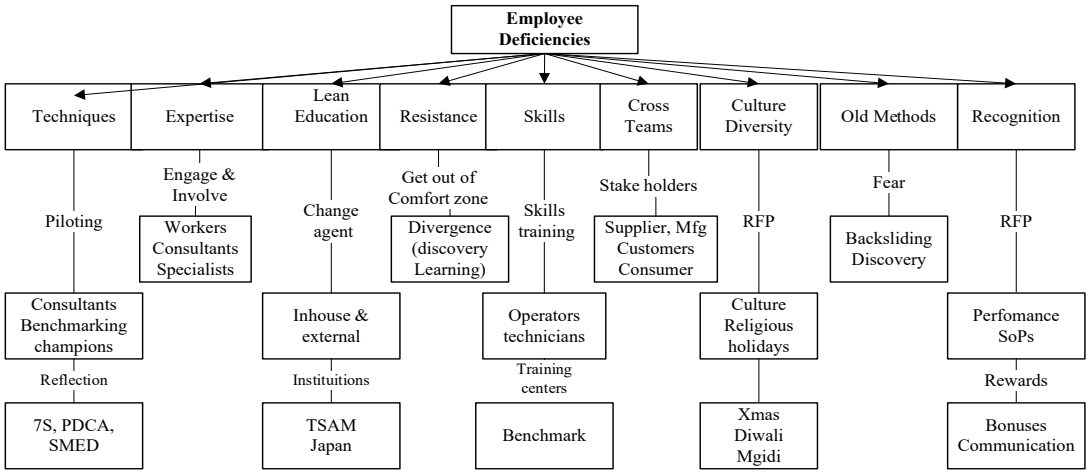

Figure 5. The Framework of the workforce area analysis (authors)

3.4 Green Supply Chain

(Mishra, 2018) commented that society is increasing environmental mindfulness and customer satisfaction to improve social, economic, and environmental protection in an organization. The barrier areas and the relationship among the barriers are used for interpretive structural modelling to set standards for prioritizing the barriers. In the ASC in question eco-design, green materials, manufacturing, distribution, training, and legislation have improved the implementation and performance of lean in the automotive industry in SA(Epoh, Langton, & Mafini, 2024). Figure 6 shows the framework for the green supply area in lean implementation.

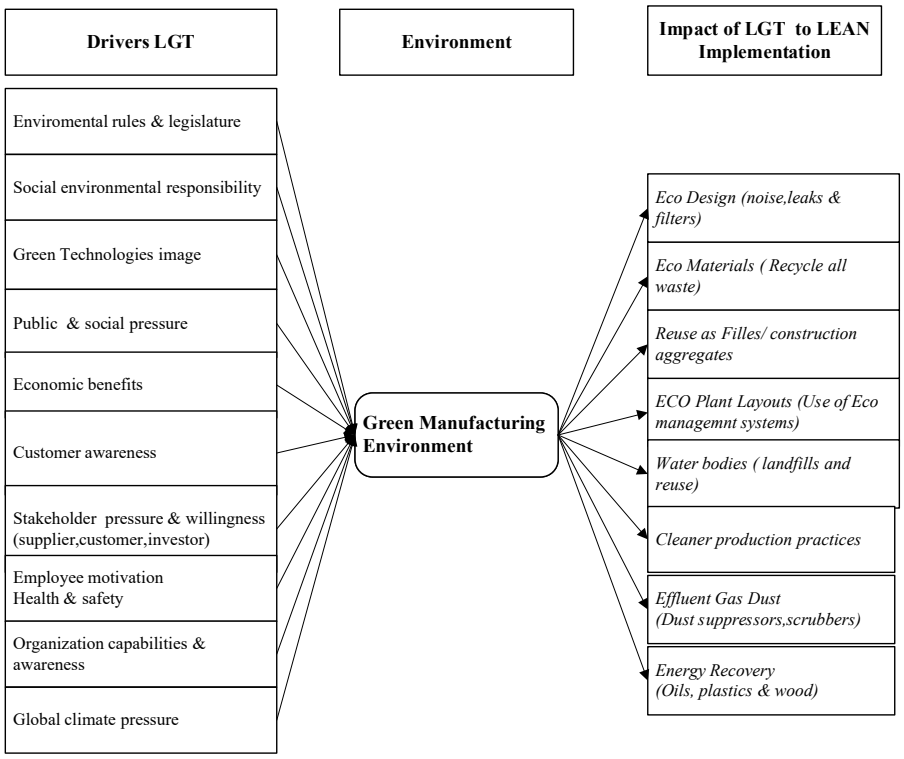

Figure 6. Framework for Green Manufacturing Supply Chain

Thekkoote (2022) developed frameworks whose focus was on eliminating all the adverse impacts of lean on the environment. Standards and enforcing green legislation are important for the socio-economic development of every community. In the South African Airlines, (Niemann, Kotzé, & Josi, 2018) carried a study on the lean green paradigm and established that Lean Greening exists in the airline to reduce costs and provide a beneficial environment that is friendly.

(Epoh, Langton, & Mafini, 2024) revealed the importance of a green supply chain in manufacturing industries concerning purchasing, eco-design, environment, materials, manufacturing, distribution, and training of employees. To control and guide the practice of greening, legislation, and regulations on product returns and reverse logistics are set up by the organization. Today we have Automotive retail and aftermarket distributors that allow returns and collect old equipment for a token to allow green manufacturing. Figure 1-4 shows the framework of the green supply chain developed in the study.

(Langton, Maotoawe, & Mafini, 2023) established that a green supply chain impacts the financial performance of a power generation company. In the study green input resources such as materials, and manpower improve financial efficiency. Green materials do not harm the environment at the end of use but form products that can be auctioned to generate income. Trained manpower ensures eco-friendly methods are used according to the legislation to eliminate the risk of fines after polluting the environment. In the automotive industry, green materials are recycled and reused whilst the workforce to their tasks in an eco-friendly manner.

3.5 Motivation

Figure 7 shows the barriers established in the motivation barrier area that need to be offset when implementing lean. Respect for people and mutual trust are key factors in the implementation of Lean that managers must consider at the workplace. This builds trust and creates a nontoxic work environment that enables continuous improvement.

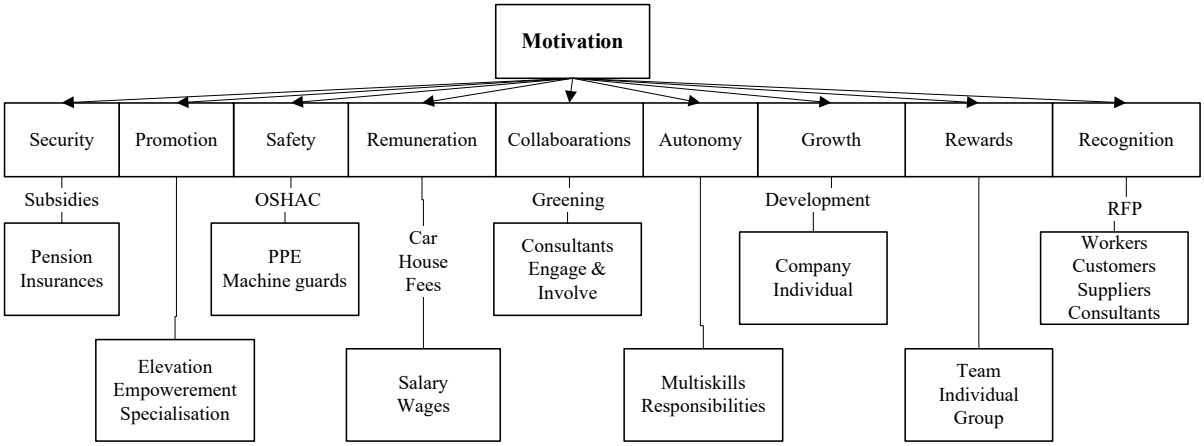

Figure 7. Framework for the motivation area

Castro et al. (2019) studied the effect of motivational factors on lean implementation in the manufacture of multinational consumer products. He considered the effect of self-expression, wear and dehumanization, responsibility, economic independence, safety, and dignity to the success of Lean. These factors were identified as motivators that enable the implementation of lean. Motivational factors were significant in improving the overall performance of a production line.

(Coetzee, van der Merwe, & van Dyk, 2016) highlighted the importance of the human aspect in lean implementation and stressed the importance of respect for people (RFP). RFP spans from the material developers and suppliers, through product development and manufacture, to the customer and end user of the final product.

(Oláh et al., 2017) showed that although the reduction of waste is the goal of lean, teaching the lean principles alone is not enough to implement lean successfully, but the employees are more important. Employees need motivation and a show of respect at the workplace. The human capital is the source of quality improvements and reduction of waste. There is a need for the automotive industry in SA to motivate workers to retain their talent by creating a nontoxic work environment that provides job satisfaction through good employer-worker relationships, remuneration, social support, and recognition. The organization must strive to attract, promote, recognize, develop, and reward the employees to retain the talent in the SA automotive industry (Macpherson, Werner, & Mey, 2023).

(Coetzee et al., 2019) expressed that the successful implementation of Lean requires the motivation of all employees and managers. Senior managers must demonstrate a high level of respect for people in the workforce. Most lean companies in the automotive industry demonstrate this when they take a Gemba walk. At some companies, the senior managers clean the whole plant once a month as a symbol of RFP.

(Amaral, Ferreira, & Ramos, 2022) and (Calderón-Mendoza-del-Solar, Montoya-Nunez, & Collao-Díaz, 2024) quantify the gains from waste reduction based on the use of the PDCA cycle as a tool in the implementation and optimization. PDCA revealed that better integration of stock management systems, plant layouts, VSM, application of quality management systems, and the adoption of effective communication systems using Kanban systems optimizes production costs.

A good employee education background is the starting point followed by training to improve commitment to learn and apply the lean tools. The organization and work environment must support the commitment of workers to problem-solving using lean principles. The non-toxic relationship between coworkers improves lean thinking. If the problem is not solved firsthand, then the PDCA cycle is applied, and standards are set to be used in the future. Rewards, recognition, green manufacturers, and good remunerations aid in promoting growth, interaction, and job satisfaction (Makwana et al., 2023).

By integrating PDCA into green manufacturing productivity increases since rejects and breakdowns will be minimized. Plant layouts, transport, motion, inventory management, and manufacturing methods which are well planned reduce the 8 wastes. The machines, methods, materials, and trained manpower will improve quality and productivity. The production process will meet and satisfy the customer demand, whilst providing job satisfaction to the workforce.

3.6 Lean Marketing

The lean marketing area framework is shown in Figure 8. Lean Marketing is a new barrier area that is critical in the SA automotive industry where it impacts greatly the retention of old customers and the creation of new ones, especially in the overseas market where suppliers from Asia have already established a big market

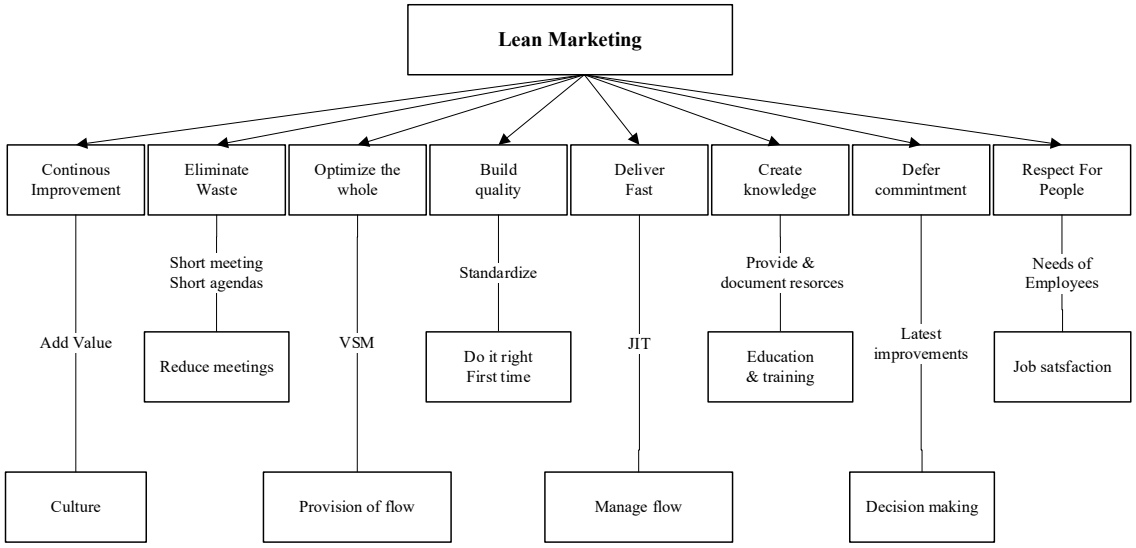

Figure 8. The Lean Marketing Framework (Author)

If the supply chain is disturbed and does not meet the demand in time the customers will cancel the orders because of breach of contract. The manufacturers need to provide good services to remain valid by improving communication technology and information systems (Ambe, 2014).

The academics (Ikome, Laseinde, & Kanakana Katumba, 2022) identified the South African Automotive industry as a pillar of economic growth for the country, and due to the global competitive challenge, the industry's economic performance is on a decline due to severe pressure from the global market. Therefore, any improvement in its competitiveness and sustainability is of great importance (Reddy & Radmore, 2023) discussed green transport where fossil fuel-driven vehicles are being replaced by electric vehicles gradually in SA. The new technology has more challenges emanating from the 100km distance the batteries can sustain and the absence of recharging facilities in transport routes.

To optimize production continuous improvement (CI) is critical to eliminate waste, build quality, and deliver fast. The workforce needs training to create knowledge and security for CI and decision-making. RFP is the driving force for the marketing barrier area.

3.7 Sustainability

(Barabaşı, 2018) considered green manufacturing sustainability is a development that meets the needs of today's generation, without compromising the ability of future generations to meet their own needs. The three dimensions of sustainability are economic prospects, ecological balance, and social responsibility. Economic sustainability is the strategy to manage resources in a way that results in long-term financial benefits. Lean manufacturing practices are among the practices that are necessary for economic sustainability. The study developed the framework Figure 9 to demonstrate the socio-economic impact of the sustainability area in lean implementation.

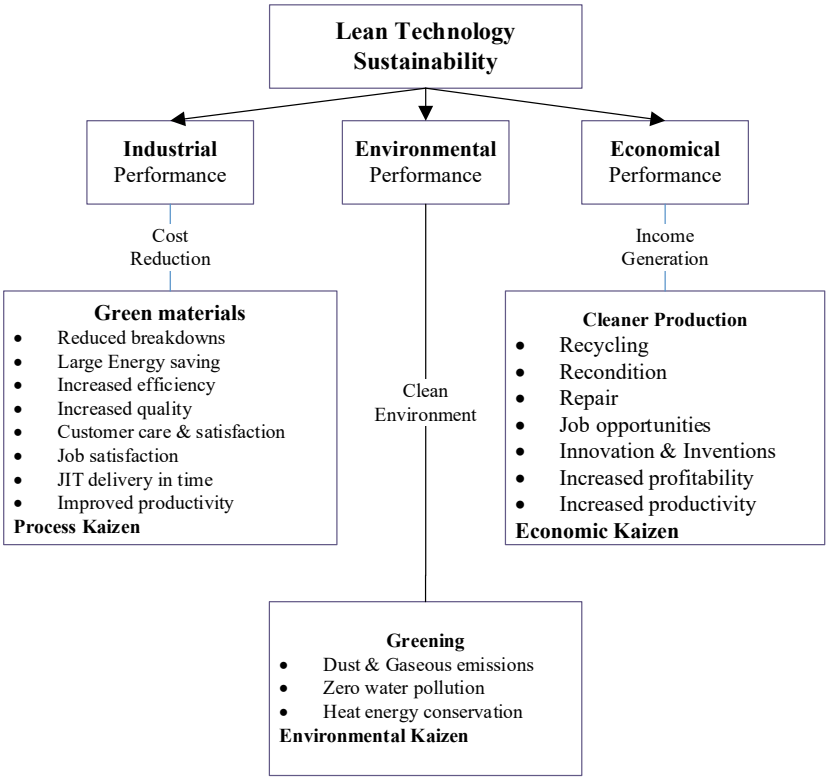

Figure 9. Green technology sustainability in Lean implementation (Author).

(Ferrazzi et al., 2024) investigated the environmental sustainability of lean and concluded that organizations' goals must align with their profitability, which could also be the complete absence of the economic and time dimensions. Lean manufacturing approach and environmental sustainability positively impact ecoefficiency performance.

(Llach et al., 2024) explored how greening enhances plant performance in the adoption of LM in a manufacturing organization. The study established the high compatibility between environmentally friendly and efficiency-driven management paradigms. This is however dependent on organizational, educational, and policy decision-making processes.

In the study by (Ferrazzi et al., 2024) factors that escalate energy costs, and heighten environmental degradation, against the market demand for eco-friendly practices compel manufacturing companies to consider greening. This would optimize operation costs and minimize waste in design and production to increase quality at reduced manufacturing costs.

The green materials, methods, machinery manpower, and designs create a green environment that allows cleaner production to take place. Any material waste and end-of-life components are converted to the downstream industry's raw materials. The process itself uses green materials that are neither toxic nor emit toxic by-products. Green materials play a big role in sustainability by reducing costs across the board from distribution through manufacturing and cleaner production of the initial waste materials.

Green distribution allows semi-processed materials to be packed in portable containers and shipped to more suppliers at a time to reduce transport and logistics costs. The Pull Kanban system is used to meet the demand of several companies in the same geographical area. This reduces the transport costs and keeps all customers supplied with the materials.

Green manufacturing is directly related to materials development. Materials are developed in a way that they do not produce toxic gaseous and liquid by-products. If they do produce toxic gases the adsorbents are fitted in the processing machines to scrub the toxic gases before they are discharged into the atmosphere. Toxic liquids

are also collected in special containers where they are stored. The fitting of special containers and adsorbents in the manufacturing system is for the safety of the workforce, machines, and environment thus green manufacturing.

Downstream industries consume the material waste as their raw materials and add value to produce products that are marketable to generate income. The collected liquid and gaseous waste are processed into raw material for the downstream industry to generate income. The downstream industry buys these byproducts and adds value to generate income in green disposal. The downstream industries create employment opportunities for society in the collection, transportation, and adding value to the initial waste materials.

Car breakers collect accident cars and break them into parts that can be reconditioned and sold or sold as they are as working second-hand parts. Any scrap is sold to scrap dealers who smelt the metals to form new ingots. For Plastic waste, they recycle the thermoplastic parts whilst thermosets are shredded to form additives or used as fuel supplements in furnaces. Rubbers are recycled to make a wide range of artifacts from tiles, mats, carpets, and mesh which are in building hardware.

4. Discussions

The economic power of sustenance depends on the profitability of the company and the success in reducing the eight wastes. In Lean manufacturing profits are not immediate but come after several continuous improvements that reduce the 8 wastes in small amounts which accumulate over time to make a significant profit. Every employee from the operator to senior managers must make improvements in the process, quality, and energy at their station. An effective supply chain uses green raw materials, manufacturing methods, manpower skills, and machinery, to customers.

4. 1 The Benefits of Seven New Barrier Areas

The seven new areas assist in implementing lean in the automotive industry. Lean philosophy helps in the environmental, economic, and social development of the community.

4.1.1 Environmental sustainability

Environmental sustainability seeks to minimize the negative impacts of human actions on the environment and conserve. Discarded waste materials are another industry's raw materials and can be converted into finished products for sale. Plastic waste is randomly incinerated at dumpsites by scavengers in search of treasure. The incineration produces dioxins and furans gases that contaminate the atmosphere and form acid rain.

4.1.2 Social sustainability

The proliferation of downstream industries creates employment opportunities for the community who collect and transport, recycle, and add value to material waste to get an income. Today the community is employed to dismantle the auto parts and engines which will be reconditioned, sold, or scraped.

4.1.3 Economic sustainability

The Automotive metal components are reconditioned and sold as second-hand parts or scraped and recycled to form metal ingots for general engineering. Thermosetting plastics are used as fuel to harness the energy value, whilst thermoplastics are recycled to produce low-grade products such as toys. Old motor vehicle tyres are shredded and converted into gym and door marts, meshed sheets, and rubber tiles to generate income.

5. Proposed improvements

Engagement and interaction with coworkers and stakeholders will increase lean implementation and allow growth to occur. Two-way feedback encourages teamwork whenever possible; anything wrong is quickly noticed since the feedback discusses more valuable issues. The preparedness to help demonstrate both parties' support for each other. By requesting what's your opinion, mutual trust is explained, and the manager expresses respect for people and their contribution to productivity. Statements such as "I would like your feedback, tell me more, I am here for you, I don't have all the answers, what do you think, how can I support you, thank you, I trust you," and so on entice core values. The security of workers which comes through employee subsidies, safety equipment, insurance, competitive wages, promotion, and recognition motivates the workforce to adopt Lean manufacturing. The security improves the morale of workers and reduces brain drain. Workers with job satisfaction are identified by the organization in the community.

6. Conclusions

The implementation of Lean was successful because it had a positive impact on the economy, society, and environment. The developed frameworks improve operational sustainability by reducing inventory, improving the quality of products, waste reduction, increase in flexibility at the operational level, and reducing cost. Each practitioner evaluates the operational performance and presents it during the reflection.

Similarly, Lean transformation improves social sustainability as evidenced by better work routines, working environments, teamwork efforts, and employee empowerment. Social impacts are qualitative measures that denote the morale of the employees. Teamwork and participation in social gatherings by employees of the same company indicate social sustainability.

Environmental Sustainability is measured by energy saving, reduced waste, and the level of pollution. A much cleaner environment is produced by the disposal of waste materials was reduced by cleaner production technologies in the downstream industries. The opening of downstream industries to convert waste into raw materials and finished products for income generation is evidence of social, economic, and environmental sustainability in the automotive industry.

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