UNIVERSITY OF KWAZULU-NATAL

A lean manufacturing implementation framework for improved productivity and efficiency in the sugar industry in Mozambique

by

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A thesis submitted in fulfilment of the requirements for the degree of Doctor of Business Administration (DBA)

Graduate School of Business & and Leadership

College of Law and Management Studies

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2022

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ACKNOWLEDGEMENT

This research would not have been completed without the help and facilitation made by several individuals and organisations. To this end, I wish to record my sincere acknowledgement and gratitude to the following individuals and institutions who sacrificed their valuable time and resources to assist in completing this research:

- Dr Christopher Chikandiwa (Supervisor), for guiding this research to completion. Through his professional help, he enhanced my learning experience throughout the study.

- Prof M.E Hoque and the late Prof Migiro, for the guidance during the proposal and initial phases of my thesis.

- The Management at the business units that allowed me to conduct my research on their facilities.

- My wife Sandra and children Takomborerwa, Taropafadzwa and Tawananyasha, for the support and encouragement throughout this study.

- Mashora E.J. Madiro, for being a supportive and dedicated research assistant.

- To my late mother and father, thank you for believing in me. You were such a gift and I thank God for having had you as my parents.

- Finally, I would like to thank God for the favour and grace he has shown me during the time of this study.

ABSTRACT

The Mozambican agricultural sector is a critical one that contributes to the country's foreign currency earnings, gross domestic product and employment. The industry is the largest employer outside the government, contributing 80% of jobs in the country, of which 70% of the employees reside mainly in rural areas. The sector, including the food processing industry, contributes 33% of Mozambique's GDP.

This study investigated the Mozambican sugar industry by identifying the critical efficiency measures, lean waste, critical lean implementation success factors, with the aim to propose a lean implementation framework for the industry. An exploratory sequential mixed method design was employed to achieve the research objectives, namely, to identify efficiency measures, lean wastes, critical implementation success factors and the building of the lean implementation framework. The qualitative component of the design was used to build the framework, while the quantitative part dealt with testing the framework developed.

Cane to sugar ratio and overall time efficiency were the two main measures critical to monitoring and driving performance for this vital sector. Various wastes unique to the sugar industry in Mozambique were identified and clustered into the known lean waste for easy analysis. The study identified the wastes and their per cent contribution: overproduction (12.15%), overprocessing (12.15%), waiting time (12.36%), transportation (12.47%), defects (12.57%), human resources (12.57%), inventory (12.63%) and motion (13.11%). Eight success factors of the lean implementation were identified: training, briefing, legal, auditing, culture, rewards, support systems and regular feedback. The framework evaluation at the AD Factory yielded significant improvement in the efficiency performance measures for that sugar mill, registering improvements on main efficiency measures of 7.3% and 0.3% for OTE and CTS, respectively.

Keywords: efficiency measures, Overall Time Efficiency (OTE), Cane to Sugar Ratio (CTS), lean waste, Critical Success Factors (CSF), Mozambican sugar industry.

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LIST OF ABBREVIATIONS

CBMS	Computer-Based Maintenance System
CI	Continuous Improvement
COVID-19	Coronavirus Disease 2019
CTS	Cane To Sugar Ratio
EBA	Everything but Arms
EU	European Union
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
JIT	Just in Time
KPI	Key Performance Indicator
LDC	Least Developed Country
LM	Lean Manufacturing
LTA	Lost Time Available
OTE	Overall Time Efficiency
RCA	Root Cause Analysis
SMED	Single Minute Exchange of Die
TOC	Theory of Constraints
TQM	Total Quality Management
UN	United Nations
VSM	Value Stream Mapping

TERMINOLOGY

a) **Preparation Index** (PI) – refers to the percentage ratio of the Brix concentration of the tumbler to the Brix concentration of the blender. It is the percentage of opened cells of cane. It measures the effectiveness of cane preparation (Cane knife and shredder). Its value should be between 90 and 92% with anything above or under results in poor juice extraction.

b) **Brix** – is the mass of total dissolvable matter in a substance, expressed as a percentage by mass. An optical instrument, a *refractometer,* can measure Brix *;*

c) **Pol** – is apparent sucrose, expressed as a percentage by mass. Pol is measured by an instrument called *saccharimeter* or *polarimeter*;

d) **Non-pol** is brix minus pol;

e) **Purity** - is the percentage ratio of pol to Brix;

f) **Sucrose** –is the disaccharide or carbohydrate, commonly known as sugar;

g) **Fibre -** is the mass of total non-dissolvable matter in a substance;

h) **Diffusion –** the process of washing the pol out of prepared cane, at high temperature (85°C);

i) **Press water** – the juice pressed out by the mills and taken back to the diffuser;

j) **Percolation** – the process by which the liquid percolates (flow) down through the bed of prepared cane;

CHAPTER 1

INTRODUCTION TO THE STUDY

This chapter highlights the study's foundation by bringing to the fore the sugar industry's role in Mozambique. As the largest employer after the government, the sugar sector contributes significantly to the overall economic performance indicators, including foreign currency earner, Gross Domestic Product (GDP) and employment. The chapter thus discusses the background of the study, rationale, research problem, aims and objectives of the study, as well as the summary of the study.

1.1 The role of the Manufacturing Industry in the Least Developed Countries

Manufacturing is a process that converts raw material to final finished goods, which customers are willing to pay for a certain amount. Bilagi and Vasanthakumara (2017) state that industries thrive on achieving perfection and maximising profit to stay competitive. According to Jones and Tarp (2015), raising productivity and efficiency in the agricultural sectors such as the sugar industry in Mozambique, must remain a top priority to achieve social and economic stability and employment creation. Compared with other emerging economies, there is vast potential for improvements in operations, efficiency, and waste reduction in Mozambique manufacturing sector (Carrilho et al., 2021). They further indicate that this sector lags behind similar sectors in the region and other LDCs

The manufacturing industry provides a solid strategic pillar to developing countries' economies (Haraguchi et al., 2017), a trend shared by Mozambique. This sector offers a sustainable foundation for economic growth, employment creation and the general socio-economic well-being of citizens in these countries (Cheong et al., 2013). According to Mozambique statistics office report INE (2021), the manufacturing sector contributes about 29 % of the GDP, making it the second-largest industry. Of this contribution,12% comes from manufacturing in the agriculture sector. Lemos and Scur (2014) note that the Mozambican manufacturing industry ranks bottom among LDCs using manufacturing management practices, thus negatively impacting its overall contribution to economic development.

Manufacturing capabilities are crucial to the socio-economic development of any country. Szirmai and Verspagen (2015) argue that manufacturing has been a critical driver of developing countries' economic growth since the eighteenth century. According to Knol et al. (2018), manufacturing enterprises are critical to developing any nation's economy, contributing to the national GDP and employment at 42% and 54%, respectively. The extent of the country's manufacturing capabilities is one of the main differentiating factors between developing and developed countries (Sami El-Khasawneh, 2012). Manufacturing in the LDCs provides a huge source of employment, modernisation through industrialisation and other positive socio-economic development indicators (Tybout, 2000).

Speering (2018) notes that manufacturing and industrialisation have been the backbone for transforming countries from low to high-income countries throughout history. Again, manufacturing drives the services sector, stimulating manufacturing production and economic growth (Speering, 2018). Manufacturing companies are known to improve the citizens' quality of life and living standards, thus guaranteeing the country's political and social stability. As a result, the standard of living in developing and emerging countries is medium to low, as compared to that of developed countries (Mamaghani, 2010).

Should manufacturing capability thrive and is sustained, Tybout (2000) asserts that it will drive modernisation and skilled workforce retention in the countries these manufacturing companies operate. Therefore, research focus efforts must aim to maintain this vital industry's survival to drive its success and improve living standards in developing countries.

1.2 Background to the Study

This section provides an overview of the sugar industry, performance initiatives in the manufacturing sector over the years. The discussion contextualises the importance of the sugar industry for the developing countries and eventually narrowed down to the context of sugar industry in the context of Mozambique.

1.2.1 Performance Improvement Initiatives in the Manufacturing Industry

Over the past decades, manufacturing firms have seen themselves adopting several manufacturing management systems and practices such as Total Quality Management (TQM), Quality management standards, Continuous Improvement (CI), Theory of constraints (TOC), Six Sigma and Lean manufacturing to improve manufacturing efficiencies (Brown et al., 2008). These efficiency and productivity intervention strategies have increased profitability by process waste elimination, customer satisfaction and improved product quality for manufacturing organisations (Resetarits, 2012).

Leksic (2018) postulated that efficiency and productivity for manufacturing sectors, including the construction sector, are heavily linked to the effective and efficient use of available resources such as people, materials and machines, among many others. Leksic (2018) further claimed that to stay in business, manufacturing and construction firms need to adopt performance-enhancing methodologies such as waste elimination, operations optimisation, improving quality, reducing costs and process improvements.

As an illustration, a study on auto industries across India revealed that performance improvement methodologies resulted in 88.22 % of defects reduction, 4.5% improvement in overall equipment effectiveness and a 7.125 hours/week reduction in downtime (Dangayach & Deshmukh, 2003). In their study, Lemos and Scur (2014) revealed that the Mozambican manufacturing industry has struggled to adopt management practices, including the lean manufacturing methodology, which is the leading system for efficiency and productivity improvements. As a result the author further notes that the manufacturing industry in Mozambique suffers largely from low efficiencies and productivity.

1.2.2 The importance of the Sugar Industry in Mozambique

According to Sathe et al. (2018), about 122 countries (66 %) produce sugar globally, most of which are located close to the equator. The sugar industries have sustained these countries' economies and have improved the population's standard of living conditions to varying degrees (Sathe et al., 2018). Predominantly, the sugar industries have provided employment and contributed sizably to the GDP of the nations in which they operate (Solomon, 2011, Ellis, 1988, Powell et al., 2014). Kotyza et al. (2021) emphasise that sugar is a major food and agricultural commodity in many developing and less developed economies. They further state that the international sugar trade is the primary revenue source for these economies and therefore, their economic stability depends on sugar prices.

The sugar sector's importance to the Mozambican economy and the livelihood of her citizens can not be over-emphasised (Buur and Nystrand, 2020, Hartley et al., 2019). The agricultural industry has been marked as the driver of sustainable economic growth in Mozambique. The sector, including the food processing industry, contributes 33% of Mozambique's GDP (Hartley et al., 2019). Table 1-1 illustrates the pivotal role played by the agriculture industry in employment, export, labour income and the overall GDP. Except for the service industry in Mozambique, agriculture is the most significant contributor to the national economy (Hartley et al., 2019).

Table 1-1: Structure of Mozambican Economy

	Share of Total (%)						
	GDP	Labour Income	Employ ment	Exports	Imports	Exports/ Output (%)	Imports/ demand (%)
Total GDP	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Agriculture, forestry, and fishing	28.5	29.3	75.4	4.6	5.5	5.9	13.6
Food Crops	20.6	20.3	40.2	1.9	4.7	5.5	20.3
Other Agriculture	4.1	4.0	10.6	1.0	0.5	6.7	7.2
Forestry and fishing	3.8	5.0	24.6	1.6	0.2	5.9	5.1
Mining	3.4	1.4	1.0	13.9	0.2	64.3	4.6
Manufacturing	11.7	8.7	2.2	47.0	74.5	40.2	63.2
Food processing	4.4	4.5	0.9	6.8	14.7	12.8	40.4
Other manufacturing	7.3	4.2	1.3	40.2	59.8	54.3	74.1
Utilities and construction	6.4	4.9	3.7	9.9	5.1	20.9	16.0
Services	50.1	55.8	17.7	24.7	14.7	8.0	6.7

Source : (Hartley et al., 2019)

Mozambique's agricultural sector has enormous opportunities to increase productivity and provides 80% employment for the country (USAID, 2012). With 70% of the workforce in Mozambique residing in rural areas, agriculture and its associated businesses employ

90% of adults (Jones and Tarp, 2015). Therefore, the agricultural sector is a well-positioned and key industry to drive socio-economic development for Mozambique and provides a pathway to improved living standards. CEPA (2016) report acknowledges that the sugar industry constitutes the second-largest agricultural export earner within the Mozambican agrarian sector, thus earning the country substantial foreign currency. Under the European Union preferential trade agreement, export has been more profitable for the Mozambican sugar industry than domestic and world markets (CEPA, 2016).

As part of the strategy to help the LDCs fight poverty, Leite et al. (2016) noted that the EU had supported the local community in sugarcane farming. Livelihoods for most rural settlers have improved through better income, employment creation and increased food production. A better standard of living in rural areas has been achieved by organising rural community members into small associations and funding their operations in the sugar industry.

1.2.3 Mozambique Sugar Industry

In Mozambique, four commercial companies (i.e. Xinavane, Mafambisse, Maragra, and Marromeu) dominate sugar production, each owning its milling facilities and they work closely with small-holder cane growers (Dias, 2013, Hartley et al., 2019). The total sugar production per province is as follows, Maputo (67%) and Sofala (33%), with the Xinavane mill contributing 50% of the total sugar produced (Chambati et al., 2019, Hartley et al., 2019). After gruesome 16 years of civil war, Mozambique's sugar industry has re-emerged as a critical manufacturing sector for employment creation and economic growth (Lazzarini, 2017).

A sizable amount of sugar cane supplied by local out-grower associations is supported by either the European Union (EU) developmental funding, or the organisation's corporate social responsibility schemes (Cambridge, 2016). A reportby Cambridge (2016) states that poverty reduction objectives, especially in Mozambique rural areas, seem to be realised, based onthe current statistics on out-growers and employment. Bågstam and Cagnan (2005) noted that although the sugar factories in Mozambique neared collapse after the civil war in 1975, sugar is now the second-largest agricultural export for

Mozambique, with the sugar industry being a significant contributor to the economy of the country. According to a report by Dias (2013), sugar accounts for 20% of all Mozambique's agricultural exports, with the bulk exported to the EU through preferential trade agreements.

Mozambique is one of the LDCs and benefits immensely from the sugar industry. The Mozambican post-independence policies identified the sugar industry as a critical strategic sector to rural development, employment and its potential to boost export earning, thereby significantly leveraging the overall economic performance (Lazzarini, 2017). Kegode (2015) revealed that the sugar factories in Mozambique account for 5% of agriculture GDP. Machemedze (2011) notes that Mozambique’s mining and gas industries contribute to more than 80% of Mozambique's total export earnings, however, the sugar industry still plays a key role by employing more than 21500 workers in the rural areas. Furthermore, Kegode (2015) showed that the sugar sector contributes about 45% of all agricultural export earnings, equivalent to 2% of total GDP and 3% of total export. According to Kegode (2015), the sugar sector's total employment contribution had grown to over 37 000 people, mainly from the rural areas, making it the second-largest employer after Mozambique's public sector. These figures highlight the significant contribution that sugar factories have had on the economy and improving people's quality of life.

Xinavane and Maragra are in the southern part of Mozambique, where there is better irrigation, transport infrastructure and closer proximity to South Africa, while Mafambisse and Marromeu are in the central province of Sofala. Xinavane and Maragra account for 67% and 33% of total sugar production for Mafambisse and Marromeu (Cambridge, 2016).

1.2.4 Challenges faced by the Mozambique Manufacturing Industry

1.2.4.1 Competition

Due to the global sugar markets, the Mozambican sugar industry is exposed to highly competitive pressures from the world’s largest sugar producers, such as Brazil, India and China (Aiuba and Nova, 2021, Ghafeer, 2021). Despite the critical role of manufacturing businesses in the countries where they operate, global market competitiveness challenges have not spared this business sector (Dangayach and Deshmukh, 2003). In support, Kumar et al. (2019) note that business pressures emanating from globalization now mean that businesses and manufacturers must do more to meet the growing and diverse customer demand at better quality and lower cost. Therefore, more than ever before, waste elimination, meeting customer needs, effective unlocking, and utilising employees' potential have become a priority and a way of doing business (Ismayil et al., 2019).

1.2.4.2 Covid-19 Pandemic

The pandemic has brought undesired business interruptions throughout Mozambique's manufacturing industry, and these interruptions have not spared the sugar sector. According to Erokhin and Gao (2020), LDCs and developing countries have had to impose export bans on most food items to address food security concerns arising from the ravaging effects of the COVID-19 pandemic. The export ban caused reduced product demand as some international markets were closed up. UN (2020) projected a drop in exports due to declining global demand for commodities. According to Solomon et al. (2020), the sugar industry and its value chain businesses have been struck by the adverse effects of the COVID -19 pandemic, mainly due to reduced demand for downstream products and a significant reduction in export markets.

Extended lockdowns experienced throughout the world have directly impacted the sugar industry and its integrated business, such as ethanol and other economically important by-products. The reduced global demand for sugar has resulted in global sugar prices plummeting, leaving the sugar industry all over the world exposed and on the brink of unprofitability. In agreement, Kotyza et al. (2021) stated that due to the pandemic, sugar market levels had been volatile on both the supply and demand sides, thereby threatening the viability of the sugar industry.

In his report, Seed (2020) correctly predicted that global sugar consumption would likely drop by 5% in 2021, mainly due to the negative impact of the pandemic. Seed further suggested that the transportation of sugar will be affected by the unavailability of ports and quarantined transit areas. Also, Solomon et al. (2020) also noted that the increasing threat of the COVID-19 pandemic to the global sugar industry would have a damaging spillover effect on integrated downstream sectors. The UN (2020) report states that the donor communities from which Mozambique benefits immensely will likely shift their focus due to the pandemic crisis, with resources being channelled to more pressing needs like fighting the pandemic.

According to the data, employee productivity has been affected, leading to tremendous efficiency and productivity issues for sugar manufacturers (Hulett, 2021). Due to the pandemic, manufacturers' top challenges are person-hours lost due to quarantine, operation stoppages, low demand, restricted business travels, delays in spare parts for equipment repairs and border closures. Mozambique's government estimates that the pandemic could result in a 7- 10% increase in the unemployment rate as Foreign Direct Investments (FDI) is expected to plummet (UN, 2020). These challenges increased the company costs per unit and shrinkage in the lucrative domestic and international markets.

The Mozambican government implemented a four-alert level approach to respond to and mitigate the rampant pandemic. These levels increase in severity from alert level 1 up to alert level 4, as indicated in Table 1-2, extracted from the Ministry of Health publishing.

Table 1-2: Alert levels in Mozambique

Level 1	**Level 2**	**Level 3**	**Level 4**
Individual prevention measures:	***Additional prevention measures:***	***Additional prevention measures:***	***Lock down:***
• Gatherings of more than 300 people banned	• Gatherings of more than 50 people banned	• Gatherings of more than 10 people banned	• Prohibition on leaving the house
• Non-essential travel to be avoided	• Quarantine for all people arriving from abroad	• Severe agglomeration restrictions in the commercial sector	• Closing of all activity in the public, private, and commercial sectors
• Quarantine for people arriving from countries with active COVID-19 cases and high transmission rates	• Cancellation of the issuing of visas	• Mandatory measures to reduce the contact between employees (only one-third present, rotation, shift work)	• Prohibition of travel
	• Mandatory prevention measures in the public, private, and commercial sectors to be implemented	• All sports, cultural, and religious activities banned	
	• Creation of a technical-scientific commission		

Source: Saúde (2020)

The Government of Mozambique declared Level 3 as state of emergency which impacted the business sector in various ways, including reduced production, banned business travel, product demand cut back due to cancellation of events and increased organisational burden to implement the required pandemic protocols (Rosário et al., 2021)

1.2.4.3 Expiry of EU Preferential Trade Agreements

After the civil war, the sustained growth of the sugar factories in Mozambique has been anchored on the guaranteed high prized market for sugar, mainly in the highly protected EU market. According to Czerminska (2021), it is without a doubt that LDCs such as Mozambique benefited more due to the availability of the lucrative EU market through preferential trade agreements.

Through EBA (Everything But Arms) trade agreement with the European Union, Mozambique gained access to the lucrative EU market in 2009 (Kegode, 2015). In their report, Cambridge (2016) concurs that it is more profitable for Mozambique to export raw sugar to European markets under preferential trade agreements, with the EU than refine it for local supply. As stipulated in the agreement, the price of raw sugar to the EU was 3 to 4 times higher than the world market price (Kegode, 2015).

The total domestic raw sugar demand for Mozambique is 200 000 tons, with the surplus of more than 300000 tons being exported to the lucrative EU markets via the ACP (African Caribbean and Pacific Group of States) and WTO (World Trade Organisation) preferential tariff rate quota (TRQ) (Chilonda et al., 2011). This predetermined quota of raw sugar imported into the EU enjoys lower duty rates, enabling Mozambique sugar to earn premium prices per ton much higher than the international market prices (Chilonda et al., 2011).

These EU preferential trade agreements ended in October 2017 and have not been renewed since then. Since the European Union removed its beet sugar production limits in 2017, the expiry of the preferential sugar trade agreements from 2017 onwards, and the depressed sugar prices globally, Mozambican sugar demand has been reduced, and the sector's profitability has suffered (Hartley et al., 2019). The expiry and non-renewal of the preferential trade agreement mean that the Mozambican sugar industry must seek alternative markets, including competing in global markets.

As has been observed, there are a plethora of benefits that the sugar factories bring to the economy of a host country. These benefits are especially true in the case of Mozambique. Therefore, this industry must stay afloat after the EU quota reforms post-October 2017. The reforms expose the previously protected industry to the rigours of the competitive world market. Accordingly, Chahal and Narwal (2017) viewed this market as a networked global market that consists of immense social, environmental and economic pressures. Survival is highly dependent on production cost, quality and technology. Several researchers have agreed that some of the pillars for survival in these intense competitive markets include low operating cost, high quality, short lead times and reliability (Drohomeretski et al., 2014, Datta and Roy, 2011). Numerous authors support this view and add that competition in the networked world market has become more robust and tough (Poksinska, 2010, Pekuri et al., 2012). Exposure to the competitive pressures of cost, food safety and high quality has made survival hard for the sugar industry operating in the LDCs, such as Mozambique

The LDCs, including Mozambique, were initially not concerned about food safety, end-customer demands and quality during exporting raw sugar to the EU, since the market was guaranteed (CEPA, 2016). This was also because the final bulk product to the EU refineries was used for reprocessing raw sugar into refined sugar and ready for customer consumption. The post-October 2017 EU reforms dictated that the sugar should be sold to the end customer (Cambridge, 2016). Therefore, strict adherence to quality and food safety is vital to compete with the global market. Food safety systems need to be set up and established at high costs to meet the stricter customer and market requirements.

As manufacturing organisations face stiff global market competition, there is a tremendous economic demand for these firms to reduce cost, improve quality, satisfy customers and increase waste elimination to survive the predatory economic environment (Chauhan and Chauhan, 2019). Brito et al. (2019) concur that businesses are under immense market cost and quality pressures, irrespective of the type of business, whether service, processing, or manufacturing. Various authors agree that the recession experienced by the global markets in the recent past has negatively impacted all industries, be it service or manufacturing (Raval et al., 2019, Sahoo, 2020, Psomas et al., 2018, Singh et al., 2009). Therefore, the industry needs to increase productivity, capabilities and efficiencies to stay in business in the new global market, with its accompanying competitive pressures (Brito et al., 2019).

1.2.5 Call to improve efficiencies in the MozambicanSugar Industry

The sugar industry in Mozambique requires increasing its efficiencies through sugar recoveries if it is to survive post-October 2017 expiry of preferential trade agreements, removal of beetroot sugar limits in the EU and receiving global prices for sugar (CEPA, 2016). Efficiency is defined as the ratio of output to input, and it seeks to capitalise on utilising existing resources such as equipment, labour and capital (Widyadhari Febriani et al., 2020). From this definition, it follows that for the sugar industry, efficiency improvement would equate to an increase in sugar and by-product outputs with minimum or no changes to all the production inputs.

Thakkar et al. (2012) submit that for the Indian manufacturing firms to be integrated into the global economy to survive, they need to develop competitive capabilities and improve operational and financial performances. To this end, Panwar et al. (2016) highlight that lean manufacturing practices should be adopted and adapted to improve organisational performance through increased efficiencies and competitiveness.

Several techniques and methods are available in the literature for improving efficiency in manufacturing environments, but the evolutionary lean is one of note (Knol et al., 2018). Lean manufacturing is known for increasing operating efficiency through efficient resource allocation and meeting customer demand while adapting to market changes and economic pressures (Furman and Małysa, 2021). Das et al. (2014) acknowledge that many manufacturing industries have adopted a lean system or philosophy to gain competitive advantage, turn around, or stay in business. Critical studies have established that for an organisation to stay afloat amidst a more turbulent and complex global market, it must improve the quality, cost, flexibility and delivery times (Anand et al., 2009, Teece et al., 1997, Fujimoto, 1999). To achieve these manufacturing attributes, Iwao and Marinov (2018) note that manufacturing organisations need to adopt lean production systems.

Chavez et al. (2015) agree that manufacturing solutions that enhance rationalised resource utilisation and reduce costs are required as a stay-in business strategy for industries exposed to the competitive global marketplace. In support of the application of lean to improve manufacturing industries' performance, literature emphasises the lean application in steel, aircraft manufacturing and electronic industries (Abdulmalek and Rajgopal, 2007, Bamber and Dale, 2000, Chan et al., 2005).

Furthermore, several researchers have also established the extensive use of lean manufacturing in the air conditioning, aerospace and radial tyre manufacturing industries has resulted in sustained efficiency, productivity and profitability improvements (Brito et al., 2019, Gupta and Jain, 2013, Wickramasinghe and Wickramasinghe, 2011). Therefore, implementing lean manufacturing tools and methodology in the sugar factories' operations will go a long way in resolving the industry's challenges of inefficiencies. Implementing lean will therefore result in its survival in the global competitive market, while meeting the ever-demanding customers.

Chahal and Narwal (2017) attest that one of the reliable strategies to survive competitive pressures in sugar factories is to adopt lean practices that help reduce manufacturing waste and improve the quality of products. In most organisations that adopted lean practices, the methodology improved lead times, quality and lower costs through waste elimination in the organisational operation and service process lines (Kovács, 2012).

In support of the waste elimination approach, Rose et al. (2010) discovered that generally in any organisation, the ratios of non-value adding activities are: 5% value-adding, 35% non-value-adding, but are necessary, while 60% of the production operations activities does not add value and can be eliminated. Based on their findings, the study recommended that it is critical for all organisations, regardless of size, to eliminate waste for improved business performance and profitability.

According to Karim and Arif-Uz-Zaman (2013), the intense global or world market competition has forced manufacturers to adopt the lean methodology approach to optimise operations and maintain profitability for manufacturing processes and operations alike. Similarly, Ismayil et al. (2019) opine that lean is a choice system in high competition and economic crisis periods. The lean approach allows organisations to invent, manufacture, and deliver products at the required quality and at reduced costs. Therefore, there is a need for a study that examines the case of improving efficiency in the Mozambican sugar factories based on lean manufacturing methodology and practices.

1.3 Rationale of Study

An extensive literature review by Sreedharan and Raju (2016) determined that the lack of a framework for implementing industry and country-specific lean frameworks is one of the five most common causes of unsuccessful lean implementation. While developing a service industry conceptual framework, Kai et al. (2020) argued that lean implementation frameworks are unique and must be developed for a specific country and sector context.

There are many different lean frameworks in the literature available for mainly the discrete industries in developed countries. Lean frameworks vary, depending on the context, country and industry they are employed and adapted to suit (Sarhan et al., 2019). In support, Basu and Dan (2020) argue that most of these frameworks are ineffective due to inappropriate application and lack of adaptation to industry and business-specific contexts. Therefore one cannot find an all-inclusive universal implementation framework applicable across all organisations, firms or industries (Basu and Dan, 2020).

An extensive literature review shows minimal lean implementation models for continuous processes and none for the critical sugar industry. Jasti and Kodali (2015) reviewed literature on the agribusiness sector, including the sugar industry. Of the 178 articles that they reviewed between 1993 to 2009, only 2.8% covered agribusiness. A review by Bhamu and Singh Sangwan (2014) found that from 209 publications published between 1988 and 2013, only 3.8% were linked to lean Manufacturing in the agribusiness sector. The lack of lean manufacturing research has left agribusiness organisations with little or no proven lean implementation framework applicable to this vital production sector. Similarly, Pepper and Spedding (2010) concluded that no standard implementation framework for lean exists universally applicable to all different countries and sector contexts.

Rachman and Ratnayake (2018) noted that some lean tools are relevant and only applicable to discrete manufacturing industries and cannot be implemented in continuous process industries such as sugar factories. Therefore, this study on a lean implementation framework is justified. According to Enshassi and Abu Zaiter (2014), it is imperative to remove uncertainties on which lean tools to apply, which ones are not applicable, and in what sequence should an organisation apply them. An industry-specific, lean implementation framework will go a long way in addressing these ambiguities and successfully guide industries to use lean strategies.

According to Flynn et al. (1990), there is a large gap between operations management theory and practice. The authors mentioned above further note that researchers focus more on conceptual and mathematical models than empirical research designs, bridging theory and practice. These models, while helpful, miss out on considering real environmental problems.

According to Basu and Dan (2020), Mozambique's manufacturing industry lacks awareness about implementing process improvement strategies, making it challenging to implement them. The gaps highlighted above create a factual basis and motivation for further research to provide various industries or sector-specific such as the vital sugar industry in Mozambique, with a custom-developed lean implementation framework. Therefore, there is an urgent need for a step-by-step implementation guide or framework for Mozambique's sugar factories. This study therefore aims to identify waste, establish challenges and critical success factors and essentially develop a lean implementation framework specific to the Mozambican Sugar Processing Factories. The framework will be tested on a selected case study unit.

The study will help provide a solution to the challenges currently being faced by sugar factories in Mozambique. The sugar industry's demise in Mozambique comes from harsh exposure to the highly competitive global network by the post-October 2017 EU sugar reforms and the adverse effects of the COVID19 pandemic. Therefore, it is necessary to conduct this study as it presents important tools that industry captains, management and policy makers can use to develop policies, systems, and best practices that would save the industry from total collapse. The study will also add to the body of literature on lean implementation frameworks for the continuous processing industry such as the sugar industry.

1.4 Research Problem

The Mozambican sugar industry is faced with highly competitive global markets due to the expiry of preferential trade agreements with the EU (Leite et al., 2016) and the adverse effects of the COVID19 pandemic (Hulett, 2021). In consequence, the sugar industry in Mozambique desperately need to build a competitive edge to avoid collapse. According to Jadhav et al. (2014), a business or manufacturing firm without a competitive advantage is not viable and cannot survive. To this end, Aga et al. (2021) emphasise that the absence of manufacturing management practices, especially the lack of lean implementation, has resulted in poor manufacturing performances in Mozambique. Manufacturing enterprises need to implement specific manufacturing approaches to keep up with the competitive pressures and remain in the profitability zone (Minovski et al., 2018). The environment in which businesses and manufacturing firms operate is rapidly changing at both national and global levels. To remain in business during challenging economic business environments, many organisations have adopted a lean approach as a system to enhance competitiveness (Taleghani, 2010).

Even though the Lean system has been adopted worldwide in manufacturing, resulting in a huge turnaround in productivity and profitability for international companies such as Toyota, it has just been introduced and has not been sufficiently adopted in developing countries (Yadav et al., 2020, Panwar et al., 2016, Zargun and Al-Ashaab, 2014). Evidence of Lean adoption in the manufacturing sector of developing countries is lacking (Piyathanavong et al., 2019).

Discrete manufacturing has used the Lean manufacturing philosophy more frequently than continuous/process manufacturing, primarily because of barriers perceived in the latter environment that have made managers unwilling to commit the time and resources (Abdulmalek and Rajgopal, 2007). Minovski et al. (2018) observed that no studies on Lean implementation in continuous manufacturing processes are available in the literature in the context of LDCs. Various authors concur that most of the literature on Lean methods has focused on developed countries like Europe and North America (Cox and Chicksand, 2005, Lyons et al., 2013, Jasti and Kodali, 2015).

Again, little research has been given to Lean implementation studies in operations studies focused on sugar factories or continuous processes (Malonza, 2014, Ondiek and Kisombe, 2012). Several researchers acknowledge that although the Lean approach has been coined and has been widely implemented by the discrete manufacturing industry, few studies have been done in the continuous process manufacturing industry (Melton, 2005, Van Dun et al., 2017). Despite the world-class Toyota system's achievements in setting Toyota as one of the best-performing companies from near-collapse, Bicheno and Holweg (2000) argue that it doesn't follow that the same results can be obtained in other different industries. Sectors such as aerospace, pharmaceutical, and continuous processing have adapted the Lean implementation framework to cater for the unique country, culture, and industry context (Bicheno and Holweg, 2000).

Veža et al. (2011) further added that very few studies had focused on Lean implementation and its impact on organisational performance in the context of LDCs. Scur et al. (2021) argue that management practices such as Lean manufacturing varies across and within countries and sectors, so one size fits all approach cannot work. The COVID-19 pandemic, global competition, falling sugar prices, and the expiration of historically lucrative preferential trade agreements have caused many headwinds to this vital industry.

Notably, there is an absence of research studies on implementing ean practices in LDCs, specifically in the sugar industry, therefore, there is a need to develop a Llean implementation framework to improve operational efficiency and productivity to save the ailing Mozambique sugar industry.

1.5 Focus of Study

This study will focus on developing a lean framework appropriate for the sugar industry in Mozambique. The Mozambican sugar industry is the second-largest employer after the government and contributes significantly to its socio-economic development, leading to peace and well-being among its citizens (Leite et al., 2016, Dias, 2019, Lazzarini, 2017, Panwar et al., 2016). The business environment for this industry has been evolving, bringing with it

According to Lemos and Scur (2014), the Mozambican manufacturing industry ranked bottom on implementing manufacturing management practices. These management practices are a bundle of operation management systems with mostly lean manufacturing systems (Lemos and Scur, 2014). Therefore, this study seeks to provide knowledge, tools and solutions to the efficiency and viability challenges that the Mozambican sugar industry faces. This study will use the Lean approach to build a framework to improve sugar industry operational performance, thereby accomplishing organisational goals.

1.6 Research Objectives

The study seeks to achieve objectives at two levels as follows:

Primary level Objective

To develop a lean implementation framework for efficiency and productivity improvement in the Mozambique sugar industry.

Secondary Level Objectives

The study sought to achieve three main secondary objectives, namely;

- To examine the main efficiency measures for the sugar industry
- To evaluate the main lean waste in the sugar industry
- To examine the critical success factors for lean implementation in the sugar factories.

1.7 Research Questions

This study seeks to answer the following question : what is the suitable lean implementation framework for the sugar factories in Mozambique, and what is its impact on improving efficiencies and productivity for a sugar processing company? The specific research questions of the study are,

- What are the main efficiency measures for the sugar manufacturing industry in Mozambique?
- What are the sugar industry's lean wastes in Mozambique?
- What are the critical success factors for lean implementation in the Mozambican sugar factories?
- What is the appropriate lean manufacturing frameworkfor the Mozambican sugar industry?

- What is the effect of the proposed lean implementation framework on the efficiency and productivity of a chosen sugar manufacturing company in Mozambique?

1.8 Justification for the Study

The sugar industry in Mozambique has played a critical role in the country and remains a cornerstone of the country's socio-economic development and employment creation (Lazzarini, 2017). The expiry of preferential trade agreements and the impact of the COVID-19 pandemic have exposed the sugar industry in Mozambique to aggressive global markets. Therefore, academics must apply relevant theories, frameworks and literature such as lean systems that improve firm competitiveness to develop an industry, context and country-specific lean implementation framework for the Mozambican sugar industry. These interventions can save the manufacturing industry from total collapse in Mozambique and avert the consequential job losses, the country's GDP reduction, and the reversal of gains made on the poverty alleviation front.

In addition, the study seeks to add empirical knowledge, thus providing a platform for further academic research. The study also seeks to avail an implementation framework in the context of the sugar industry in the LDCs, thus providing a foundation for future research using the framework or conducting further tests on it.

The industry will be provided with a critical tool in the form of a lean implementation framework needed for performance management and improvements. The performance efficiency improvement lean manufacturing framework for the sugar industry was availed, thereby helping the industry navigate the global pandemic challenges, expiry of the EU preferential agreements, effects of the COVID-19 pandemic and other rising competitive pressures emanating from the global sugar markets

Finally, this study was essential for governments to use as a guide and support when making policy decisions regarding the manufacturing sector. Policymakers were provided with a lean manufacturing framework specific to a country and industry context. Relevant information required to shape the policy framework affecting the manufacturing industry, specifically the crucial sugar industry, can be drawn from this study.

1.9 Outline of the Thesis

This thesis is presented in eight chapters as follows:.

Chapter 1 introduces the research problem and the background explaining why the topic is a matter of interest. Based on the background and research problem, the study's objectives are presented together with the research questions. The chapter also highlights the scope of the study, its rationale and its limitations.

Chapter 2 provides a basic understanding of the sugar manufacturing processes and common terminology used in the sugar industry. Standard definitions used in this industry are described, while the chapter also sets a foundation for understanding the principles and concepts commonly used in the study.

Chapter 3 presents the literature underpinning the study. The review analyses the existing theory and empirical research findings on the lean philosophy. Furthermore, it details the main lean implementation principles .

Chapter 4 describes the research methods and processes carried out to achieve the objectives of the study. The chapter highlights the research philosophy, data collection and analysis methods.Furthermore, issues of validity, reliability, and generalisability are also discussed.

Chapter 5 provides results presentation from the Delphi technique processes, showing opinions and issues raised by the panel of experts and quantifying the level of consensus achieved by the participants. The chapter also presents the profiling of the panel of experts' results from the selection criteria given in the methodology section.

Chapter 6 details the discussion of findings,pointing out the recommended lean implementation framework for Mozambique's sugar factories. As part of achieving the research objectives, this chapter presents the proposed lean framework and the respective motivation why the constructs are suggested.

Chapter 7 presents the results and rigorous analysis of the proposed lean implementation framework's impact on the case study. This chapter intends to achieve the research objectives, answer research questions, and discuss how this study contributes to scientific knowledge.

Chapter 8 forms the conclusion and recommendations on the findings, and the results in Chapters 5, 6 and 7 have been condensed and interpreted considering the study's objectives. The limitations of the study are also highlighted and potential future research in this area is recommended.

1.10 Chapter Conclusion

This introductory chapter laid the basis for the study. It introduced the background to the study, the research problem, the ensuing research objectives and the respective research questions. Subsequently, the research was justified, and the thesis structure was outlined. The thesis proceeds with a detailed description of the research on these foundations, beginning with a thorough examination of lean manufacturing literature in the following chapter.

CHAPTER 2

RAW SUGAR PROCESSING OUTLINE

2.1 Overview

This chapter provides a basic understanding of the sugar manufacturing processes and common terminologies used in the sugar industry. Standard definitions used in this industry are described and set a foundation for understanding the principles and concepts commonly used in the study. The sugar manufacturing processes are split into main function areas and classified depending on the key result output of each process line. The primary functional areas in a typical sugar factory are cane preparation, sucrose extraction, juice evaporation, crystallisation, curing, drying and steam and power plant.

2.2 Sugar processing

Mills use sugar cane as raw material to make sugar. Hugot (2014) states that sugar cane consists of roots, leaves, as well as stalks that contain those cells. 15% of cane is composed of fibres, 15% dissolved matter (13% sucrose, 2% glucose and fructose) and 70% water. Pack (2010) explains that sugar is extracted from a giant tropical grass called sugarcane which stores energy in its stalks in sugar, then extracted for human consumption. According to Rein (2011), the sugar industry is a well-placed agro-business with many environmental advantages, namely fibre for renewable energy generation, biomass and non-toxic or hazardous products. The sugar industry is considered one of the oldest industries and the world's most important industries consisting of cane cultivation, milling, extraction and crystallisation processes (Galloway, 2005). For Rein (2009), the primary sugar manufacturing process flow follows bagasse cane extraction, heating, clarification, evaporation, crystallisation and centrifugation with raw sugar and molasses as products. Other authors agree that although sugar manufacturing processes may vary from one organisation to another, the basic processes are common across the whole board: cane harvesting, cane preparation, juice extraction, clarification, evaporation and crystallisation (Chen and Chou, 1993, Hugot, 2014, Delgado and de Armas Casanova, 2001).

Nazlioglu et al. (2013) explain that sugar is a commodity; therefore, organisations compete mainly on product pricing. Thus, sugar mills must reduce the total cost of production to survive the brutal industry competitive pressures on the world market. Concurring with the fact that cost is a significant factor in the international markets, Radošević et al. (2013) concluded in their study of the sugar industry in Serbia, that cost was the main reason why the industry was not competitive. In his submission, Patil (2017) postulates that one of the ways to reduce costs in a sugar mill is to benchmark, set standards and seek to perform to the standards. Patil further emphasises that these standards adopted should enhance mill efficiency, productivity and product quality.

The manufacturing facility process flow at the sugar factory is summarised in four major processing blocks: cane preparation, juice extraction, sugar production (juice clarification, evaporation, crystallisation, curing) and packaging station (de Souza Dias et al., 2015). Within the sugar processing blocks, different key processing parameters feed into the overall efficiency of the factory. Thus, once each processing parameter within the block has been improved, the overall factory efficiency measures are improved.

2.3 Sugar manufacturing process flow

Figure 2-1illustrates a common raw sugar factory highlighting the process flows and typical performance parameters used for controlling process operations.

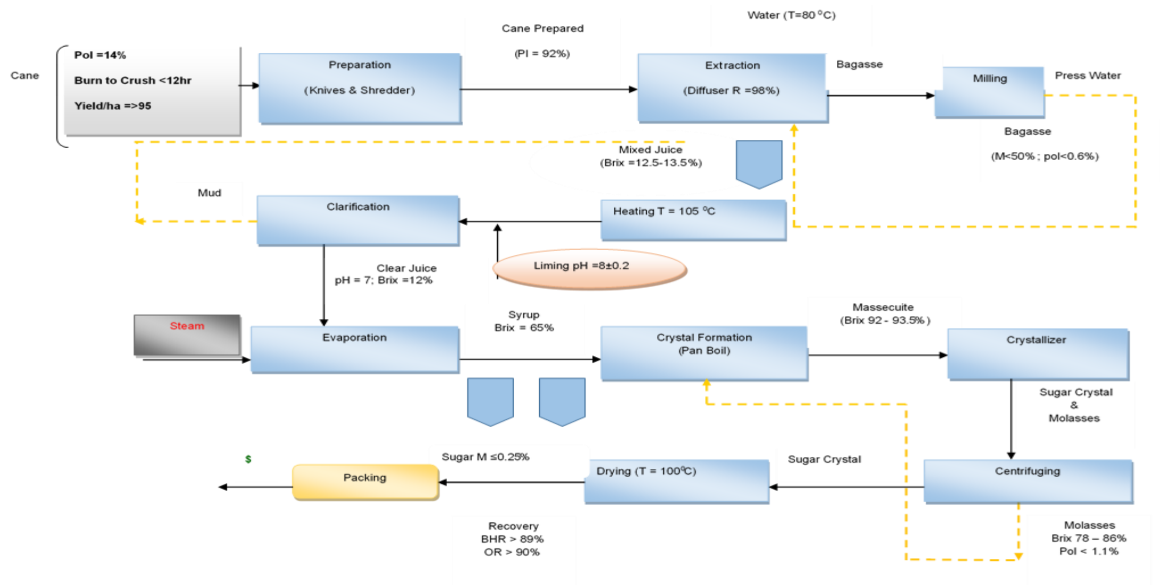

Figure 2-1: Manufacturing process flow

Source: (Researcher's Compilation)

As highlighted above, only the indicators considered are those applicable to the process flow from receiving the raw material sugar cane processing it and ending on the weighed final product, which is raw sugar.

2.3.1 Cane preparation

According to de Souza Dias et al. (2015), cane preparation is when the cane is finely broken up to expose cells containing sugar by using knives and hammers before juice extraction, through milling or diffusion. Similarly, Rein (2011), (Bocha, 2019) contend that cane preparation reduces sugar cane into smaller shredded pieces to ensure efficient sucrose extraction. The commonly used method for cane preparation is knives first, then shredders to achieve maximum cell exposure and enhanced characteristics required for an efficient diffusion process during the extraction stage (Jenkins, 2013).

2.3.2 Cane Preparation Performance Parameters

2.3.2.1 Burn to Crush hours

The lag between the time cane is cut and delivered to the mill is crucial for the raw cane material quality. Once the cane is cut, the pol or sucrose starts deteriorating, breaking down to form some forms of sugars that cannot be recovered. The shorter the duration between burn cut and processing of the cane, the better the sugar factory recovery performance. Patil (2017) asserts that world-class sugar mills have set a standard burn to crush between 8 to 12 hours. Table 2-1 shows losses associated with a time lag between harvesting and crushing of cane.

Table 2-1: Recovery and Weight Loss of Sugarcane

The time lag between harvesting and crushing in hours	**Weight loss per ton of cane in kg**	**Sugar loss per ton of cane in kg**	**Recovery loss per ton of cane in units**
8	14.00	1.45	0.145
16	17.50	2.90	0.290
24	29.00	3.99	0.399
32	39.80	5.66	0.566
40	57.50	7.73	0.773
48	64.70	8.65	0.865
56	73.80	11.45	1.145
64	77.00	13.52	1.352
72	83.00	15.16	1.516

Source (Patil, 2017)

2.3.2.2 Cane Tons Crush Per Hour (TCH)

This is a measure of production crushing rate referenced on per hour or day basis. This crushing rate can also be referred to as the utilisation rate for the factory. Researchers confirmed that reviewing capacity utilisation is reliable for measuring and evaluating sugar mills' productivity (Akpan et al., 2013, Bocha, 2019). In their study on capacity utilisation for the Nepalese sugar industry, Akpan et al. (2013) determined that a utilisation rate of 85% was low and unacceptable, while a 98% rate was considered good. Singh (2007), in his study on the comparison of mill performances in India, considered 99.40% as an efficiently run sugar mill.

2.3.2.3 Electric Energy Demand

For sugar factories, power generation capacity is inadequate to supply all the estate electric power demand; hence, importing energy from the utility is essential for meeting electrical power requirements (Hugot, 2014). Therefore, process electrical energy demand control is crucial to lowering imported electrical energy costs. The standard process energy demand for similar-sized operations in the major sugar-producing countries such as Brazil and India is 12kWh/ton of cane (Ensinas et al., 2006, Gil-Donato, 2016).

2.3.2.4 Lost Time Available

Lost time available (LTA) is defined as a percentage of time lost due to sugar mill equipment or process unavailability and is expressed as a percentage of available time. Patil (2017) reckons that the stoppages may be due to mechanical, electrical or operations breakdowns. The major causes of the lost time are unplanned equipment stoppages due to breakdowns and process stoppages due to unwarranted processing deviations. A study on mill operation performance by Singh (2007) revealed that the best and world-class Sugar Mill performance achieves 2.5% LTA in a given crushing season.

2.3.2.5 Cane Preparation Index (PI)

The cane preparation index is the ratio of Brix in the ruptured cells to total Brix in cane expressed as a percentage; this measures how exposed the cane cells are after the cane stalks are cut and shredded. The objective of cane preparation (Kent et al., 2022) are:

- to reduce the size of the pieces of cane to an extent suitable for handling in the extraction process;
- to rupture as many of the sugar-bearing cells in the cane to facilitate the extraction of sugar;
- to produce a material that has suitable characteristics for milling and diffusion.

Hugot (2014) states that the best in the industry sets a target of a cane preparation index of 91%-92%. Concurring with this view, Mbuyazi and Mhlongo (2014) allude that a preparation index of 92 % must be the target to achieve an above 97% extraction.

2.3.3 Juice Extraction

This process extracts sugar or sucrose from the ruptured cells through either diffusion or mill squeezing. Rein (2011) contends that extraction is the separation of juice from the fibre, and the two standard methods for sucrose extraction is diffusion or milling.

2.3.3.1 Milling

A process of sucrose extraction through milling is achieved by squeezing the prepared cane between a pair of rollers and washing it, a process repeated on several milling units, usually six, to maximise sucrose extraction (Rein, 2011). Milling begins with a dry extraction and from there, the cane goes through a process called imbibition, in which hot diluted cane juice or water is added to help remove sugar from the cane fibre employing a process known as leaching (Buchanan, 1965, Rein, 2011, Bizzo et al., 2014). The primary juice from mill stage 1 and the secondary juice from mill stage 2 are mixed for further processing, while juice from mill stages 3 and 4 is returned to mill stages 1 and 2 for imbibition (Buchanan, 1965, Bocha, 2019). Mill stage 6 is usually used as fuel for dewatering and drying bagasse to generate high-pressure steam and electrical energy (Rein, 1995, Kumar and Arora, 2021).

2.3.3.2 Diffusion

According to Rein (2007), diffusers employ two sucrose extraction methods, washing and diffusion. Washing removes sucrose mechanically from the fibre surface, while diffusion involves sucrose being transported from fibre cells with a high sucrose concentration to the surrounding medium with a low sucrose concentration (Balkissoon, 2020).

Several authors posit that a diffusion extraction method is the most popular alternative to milling extraction in Southern Africa, which is used by 90% of sugar factories (Meyer et al., 2013, Smith, 1978, Kwenda, 2015). Diffusers have become more popular due to their higher sucrose extraction rates and lower costs of capital, maintenance and operation (Eggleston et al., 2013).

2.3.4 Juice Extraction Performance Parameters

2.3.4.1 Extraction

The extraction occurs on the diffuser, and it is a measure of x percentage of total pol in the cane that will be carried forward as a raw material for the following processing block. According to Rein (2016), key parameters that affect extraction are diffuser retention time, imbibition water temperature, imbibition rate, mud return, Brix profile and pol in bagasse. The industry standard imbibition rate is 350 % of fiber and a temperature of 80°C to be maintained in the diffuser for profitable extraction of 98% (Masenda, 2022, Seebaluck and Sobhanbabu, 2013).

2.3.4.2 Pol % Bagasse

The diffuser has two outputs, bagasse or fibre, used as fuel to generate energy, such as steam and electrical power. The pol in the bagasse by-product must be minimum with theory dictating that a lower pol per cent in bagasse results in higher pol recoveries with minimal losses. Accordingly, Mbuyazi and Mhlongo (2014) record that for a similar sugar mill, Felixton, a pol per cent bagasse of less than 0.6 was achieved.

2.3.4.3 Bagasse Moisture Per Cent

High moisture in the by-product (bagasse) means increased chances of losing pol (sugar) to the boilers and secondly, loss of the calorific value for the fuel value, thereby losing potential energy. Moisture measurement captures one of the critical performances of the milling dewatering mills. A target of 50% has been consistently achieved by Felixton Sugar operation with the same diffuser and dewatering configuration at the AD Sugar factory. The 50% target value, according to Mbuyazi and Mhlongo (2014), ensures a high energy recovery from bagasse as fuel. In terms of efficiencies, more bagasse is required to produce 1 ton of steam. Alena and Sahu (2013) point out that the net calorific value in bagasse decreases with increasing moisture content.

2.3.5 Evaporation

After the juice has been extracted from the milling or diffusion processes, it is directed to the evaporator station for further concentration. Once the juice has passed through clarification, raw juice is then sent through the evaporation system which removes water by boiling to increase the soluble solids concentration to around 60-65 Brix, and sugar composition of about 3.5 to 4.5% (Jorge et al., 2010). de Souza Dias et al. (2015) also note that concentration is usually achieved by passing the juice through multiple effect evaporators consisting of Robert evaporators with 4 to 5 evaporation steps. Basically, the concentration measured in Brix units is picked up from about 15 Brix at the feed point to about 65 Brix at the last evaporation stage (Rein, 2007).

2.3.6 Evaporation Parameter Controls

2.3.6.1 Boiling House Recovery

Juice from the preparation and extraction process block is called mixed juice and is the primary raw material input to the Boiling House process block. Gunawan et al. (2018) extol that the efficiency of the boiling house is measured by the parameter boiling house recovery (BHR). Shoonees-Muir et al. (2009) define the Boiling House Recovery parameter as a ratio of recovered pol in sucrose over the total pol in mixed juice expressed as a percentage. Several essential control and performance measures are monitored within this process block to minimise process deviations. Some of the parameters include steam temperature, mixed juice temperature, steam pressure, mixed juice pH, syrup Brix and final molasses purity. Gunawan et al. (2018) noted that the best in industry boiling house recovery standard number is 90%. The authors further reveal that a figure of 98.9% is achieved by the best in the industry; an example is the Mauritius sugar mill.

2.3.6.2 Mixed Juice Temperature

Mixed juice should be at a specific temperature range below which microbiological activities will start degrading the quality of the juice resulting in pol losses (Tarafdar et al., 2019). Temperatures higher than recommended cause sugar conversions which again result in pol losses.

2.3.6.3 Mixed Juice pH

The final pH going to the evaporators should be maintained slightly alkaline (7.1 -7.5) in order to avoid sucrose losses by inversion (when the value is below) and high Massecuite viscosity, which results in crystallisation difficulty due to insufficient flow of the material (Rein, 2007). According to (Sahula, 2015), monitoring the total reducing sugars is essential as it is a quality control pillar of any sugar manufacturing processing. These reducing sugars increase with a drop in pH (acidity) and result in product caramelisation, leading to lost product quality. Panpae et al. (2008) reiterate that this causes a significant problem in sucrose or pol losses and that most authors agree that suitable mixed juice pH must be in the range of 7.1-7.5.

2.3.7 Crystallisation

The crystallisation process involves precipitating sucrose crystals (Delgado and de Armas Casanova, 2001). As with evaporators, water is removed from the syrup before sucrose crystallisation, which creates mother liquor (liquid fraction), a mixture of sugar crystals and syrup (Chandel et al., 2014). According to Rein (2007), the syrup is heated in boiling pan A, until it reaches a certain level of supersaturation, and then crystallisation is initiated by mixing seed sugar from the C pans with water, which acts as nuclei to initiate crystallisation. Rein (2011) recommends that the syrup concentration be maintained at a constant level of supersaturation throughout the processing phase to ensure further crystallisation. To separate A sugar from A molasses, the A massecuites are drained from the A pans and centrifuged. In the sugar mills, A molasses feed pans B and B molasses feed pans C, producing C sugar and C molasses (Hugot, 2014).

2.3.8 Centrifuging

After a specific residence time, the massecuite is transferred to the crystallisers which generally consist of mixing tanks with a cooling system where sucrose is allowed to crystallise before centrifuging (Rein, 2011). Hugot (2014) points out that the massecuite in the crystallisers is sent to centrifuges to separate crystal from run-off syrup (mother liquor), in which hot water and steam are used to wash the crystals. In addition, Srichaipanya and Chuan-Udom (2020) assert that sugar crystals are separated from massecuites by centrifugation and it involves spinning the massecuites, which separates the liquid from the crystals. Before being sent for drying, the crystals are rewashed to remove the remaining molasses (Rein, 1999). The mother liquor is drained from a batch centrifuge, leaving a cake of sugar crystals behind. A thin layer of mother liquor remains on the sugar crystals, which is removed by adding water or steam to the centrifuge basket (Hugot, 2014).

2.3.9 Sugar drying

In rotary drum dryers, the sugar produced in the centrifuges is usually dried to around 0.05-2.0% moisture content, depending on the type of sugar produced, before cooling and being stored for packing and distribution (de Souza Dias et al., 2015).

2.3.10 Crystallisation and Centrifugal Control Indicators

2.3.10.1 Overall Recovery

Overall recovery (OR) in a sugar mill is defined as the mass percentage ratio of total mass pol in the sugar of total pol in cane. The formula to calculate OR is given below and is the most critical sugar factory performance indicator.

*Overall Recovery = (Pol in Sugar/Pol in Cane) *100*

According to Inman and Chow (1998), the overall target recovery should be > 90%. The authors further state that this is the figure that is achieved in Australian sugar mills.

2.3.10.2 Total Losses

In any sugar mill, sugar losses are bound to happen, but they should be managed to remain as low as possible. The more sugar losses are in the processing line, the higher the cost per unit of sugar made. As alluded to before, it is not easy to compete in this market with a higher than the standard unit cost of production. Patil (2017) reports that the total sugar loss permitted in a world-class sugar factory is 1.75% maximum, excluding filter cake losses for diffuser-operated factories. The total losses permissible of 1.75% are allocated in the following manner, sugar in bagasse at 0.60, sugar in final molasses at 1.10 and undetermined loss set at 0.05. Patil gives the best in the industry individual loss percentages on the other processing losses that may occur across the processing line.

2.4 Efficiency in Raw Sugar Manufacturing Processes

The sugar industry is essential for developing countries and contributes significantly to these countries' overall economic performances. The industry is under threat from various problems such as withdrawal of trade agreements, reduced productivity, global competition and lower efficiencies (Datta et al., 2000, Reddy, 2003, Raheman et al., 2009). All the highlighted processing or manufacturing steps should be executed efficiently, with Raheman et al. (2009) noting that without improving the sugar industry productivity and efficiencies, the industry will not survive in the global market. Datta et al. (2000) accentuate that the processing capabilities and efficiencies of sugar manufacturing mills are critical for the continued existence of the Indian sugar industry.

According to Reddy (2003), the only way to survive the post-Fiji/EU preferential trade agreement in 2007 was for manufacturers to increase their productivity and efficiency in all factory value chain and sugar processing steps. A study by Johan (2021) on the Indonesian sugar industry concluded that adopting and implementing efficiency and productivity improvement systems for sugar manufacturing factories is necessary to avoid the sector's collapse. Concurring with the submissions of the various authors noted above, Arkeman and Fewidarto (2021) emphasise that the improvement of manufacturing processes efficiency for the sugar industry is the single most crucial strategy that can be implemented as a stay in business strategy in this current challenging environment. Therefore, it is reasonable to conclude that improving sugar manufacturing productivity and efficiencies gives the critical sugar industry a significant chance of survival.

2.5 Conclusion

This chapter described the raw sugar manufacturing process flows, following the main raw sugar mill product, which is raw sugar. The operations were split into sections for easy navigation.Cane preparation was described, where cane is prepared and made ready for sucrose extraction, either by a milling tandem or in a diffuser. The value chain proceeds to the cane juice extraction, where sucrose is extracted from the raptured cane cells. The extraction takes two primary forms: mechanical washing of cells and diffusion of sucrose from a region of higher concentration to that of low concentration. After extraction, the mixed juice containing the sucrose will then pass on for further processing at the evaporator station and crystallisation sections, where basically, water from the extraction plant is evaporated, the sucrose is concentrated and crystals are formed. In the last stage discussed, the concentrated sucrose is then passed through a centrifugal station to recover the crystals and then dried to remove moisture in the final sugar product. Control parameters and specifications were discussed, while operational targets were established from the literature.

CHAPTER 3

THEORETICAL FOUNDATIONS AND LITERATURE REVIEW

3.1 Overview

This chapter provides an in-depth analysis of the theoretical foundation upon which this research is premised. This analysis was achieved by reviewing the relevant literature to identify research issues worth researching because they are controversial and have not been answered by previous researchers. Thus, the rigorous study of literature is not an achievement of the research objectives, but it identifies the worthy research issues around the research topic and firmly embeds this research in the body of knowledge.

First, the chapter begins by mapping how and where the literature review sources were obtained. Secondly, the chapter presents rigorous theoretical frameworks on manufacturing industries' efficiency and productivity improvement techniques. A funnel technique was used to explore relevant but broad concepts and lean implementation emerged as the most appropriate framework. Thirdly, an empirical literature review on lean implementation was carried out by sifting through the latest relevant academic research. Fourthly, the study interrogated the various research methodologies used by researchers in related prior research studies. Where appropriate, the study extracted guidance on how to proceed with carrying out this research to ensure that it is relevant and firmly founded in the overall academic knowledge. The chapter concludes with the main lessons and how this research is deserving of investigation.

3.2 Theoretical Foundations

This section discusses and reviews the theoretical foundations on which performance improvement initiatives, frameworks and philosophies are founded. The unit focused on the five primary theories that help to explain the efficiency and productivity approaches, such as lean manufacturing methodologies.

3.2.1 Theory of Efficiency and Productivity Improvements

Theoretical deficiencies in operations management have repeatedly been criticised as the research into this field has become more rigorous over the years, with organisations' operations management suffering as a result of a lack of recognised underpinning theory for performance improvement systems (Swamidass and Newell, 1987, Anderson et al., 1989, Swink and Way, 1995, Flynn et al., 1990, Schmenner and Swink, 1998).

According to Vilkas et al. (2021), several operations and manufacturing strategies such as pean production (LP), Total quality management (TQM), and bullwhip effects are underpinned by multiple theories whichinclude the theory of Swift, Even Flow, Theory of Constraints, Queueing theory, Resource-based view theory and the theory of performance frontiers. It is the submission by various authors that the implementation of global manufacturing strategies and efficiency improvements systems such as lean, Six Sigma, TQM and many others find their theoretical basis in the Resource-Based View theory (Punnakitikashem et al., 2009, Farrukh et al., 2021, Manzoor et al., 2021). Handfield and Melnyk (1998) further add that to understand lean operations at a high level, it is necessary to understand a wide range of individual theories that make up the theoretical foundation of lean manufacturing. Multiple theories have been attributed to the phenomenon of lean production, which increases productivity in several ways (Vilkas et al., 2021).

3.2.2 The Theory of Swift, Even Flow

Schmenner and Swink (1998) developed the "swift even flow" theory which states that the more the swift and even factors of production move in the process, the higher the productivity. This theory gives a theoretical foundation for the relationship between lean manufacturing and productivity. Lean manufacturing methodology follows the principles of swift and even flow theory by reorganising layouts, standardising routine tasks, visually redesigning facilities and workplaces, as well as eliminating waste relentlessly (Vilkas et al., 2021).

The Theory of swift, even flow states that a process is more productive if materials flow smoothly and evenly. Productivity rises with increased flows of materials and declines with greater variability, regardless of whether it is caused by inside or outside factors (Schmenner and Swink, 1998). Several theoretical constructs constitute the Theory of Swift, Even flow, and these are explained by Schmenner and Swink (1998) as follows:

3.2.2.1 The Concept of Value-Adding and Nonvalue-Adding Work

Value-adding activity is a process or work that converts raw materials to finished products or goods, while non-value-adding is activities such as material movement, inspections, and reprocessing, which do not add value to the final product. Shingo and Dillon (2018) add that there are seven main non-value-adding activities: transportation, inventory, overprocessing, motion, waiting, overproduction, and defects. These non-value-adding activities constitute waste the theory of Swift, Even flow targets eliminate or reduce these wastes.

3.2.2.2 Process Debottlenecking

Debottlenecking is the theory's second construct that seeks to achieve the swift movement of material along and across the entire process line. To accomplish swift movement or even flow, the theory employs the throughput time concept to measure the speed of material flow from entry until finished goods are delivered to the warehouse or the customer.

3.2.2.3 Process and Demand Variability

The standard deviations or variances between the timing or quantities delivered or times spent on various processes measure the variability of demand or process. The theory states that the less the demand or process variability, the better the productivity or performance of an entity as production plans are evenly executed. Whenever possible, it is also recommended that products or processes be run parallel to narrow variability and ultimately increase the productivity of an entity.

3.2.3 Queuing Theory

Queueing (waiting line) theory has been around for a long time among the most established theories in the field. It is a mathematically based theory developed in 1909 by Erlang. It explains the queuing phenomena found in virtually all operations (Vilkas et al., 2021). According to Tadj (1995), in queuing theory, the objective is to analyse this phenomenon to find an optimal method to solve this problem without keeping people waiting for a long time.

Currently, queuing theory is widely used in manufacturing production planning and computer systems to assess performance and stay competitive in these rapidly growing global markets (Afolalu et al., 2019). A manufacturing entity always has products or work in progress waiting to be picked up or moved to the following processing step. The longer the waiting time, the less efficient the operation. Therefore, manufacturing firms need to control the waiting time in the processing lines, thereby improving productivity and efficiencies (Pangastuti and Setiawan, 2020). According to Li et al. (2020), the queuing theory helps organisations in the service and manufacturing sectors to be more efficient and effective in delivering services and goods to customers, thereby maintaining their competitive advantage.

3.2.4 The Theory of Constraints (TOC)

Goldratt developed the theory of constraints in the 1970s to provide a coherent management theory for running an organisation. The central concept of TOC is that in every system, there is at least one constraint that restricts a system or process from attaining better performance and its goal, and the second concept is that these constraints present an organisation or manufacturing operation with an opportunity to keep on improving (Goldratt, 1988).

This theory consists of two significant constructs or principles, i) the principle of continuous improvement and ii) the generic approach to problem-solving called the thinking process (TP) (Rahman, 1998). According to Boer et al. (2015), the role of management is to focus on the identified constraints and action to eliminate them, leading to improved efficiency, productivity and competitive performance of a manufacturing organisation.

3.2.5 Theory of Performance Frontiers

Schmenner and Swink (1998) developed the theory of performance frontiers which seeks to maximise performance by improving an organisation’s operating policies while maintaining the same cost level or by investing in assets. The authors mentioned above further explain that with the operating frontier, performance or efficiency improvement with little or no change to production inputs is achieved by aligning its operational policies to match its physical assets' capabilities. The second is the asset frontier, where performance is improved through plant design and investment or capital expenditure into fixed assets (Schmenner and Swink, 1998). Vastag (2000) notes that the asset frontier is determined by tangible resources, while intangible resources determine the operating frontier. To assess their manufacturing strategy, firms must analyse their business environment, and review their performance frontiers, namely the assets and operating capabilities (Cai and Yang, 2014).

According to Vastag (2000), it is easier to achieve a competitive advantage by leveraging the operating frontiers of organisations than by using assets frontiers, as operating frontiers represent unique resources that are valuable, rare and specific to a particular company. An organisation's performance frontier depends on its asset frontier which determines the maximum performance possible based on assets' capabilities and utilisation, and its operations frontier, which represents its ability to achieve maximum performance based on operating policies (Boer et al., 2015). The unit's operational frontier determines the manufacturing efficiency, which in turn is limited or restricted by its asset frontier (Cai and Yang, 2014). It follows then that a manufacturing organisation or any service sector can improve their efficiency and productivity performances by enhancing their current processes and operating policies (Boer et al., 2015).

3.2.6 Resource-Based View Theory

The resource-based view (RBV) in the strategic management context refers to business management tools that can be used to determine the strategic resources available to the firm. RBV considers superior competitive performance to be a function of specific competencies of the firm that are heterogonous between firms and are derived from resources. The primary principle behind RBV is that the basis for a firm's competitive advantage lies predominantly in how the organisation utilises its resources to outperform its competitors. However, these resources need to be heterogeneous in nature to transform a short-run competitive advantage into a sustained one. Resources are a firm's specific assets, they can be the current activities of an organisation and can be physical, human and organisational (Barney et al., 2001, Eisenhardt and Martin, 2000).

For a resource to contribute to a sustained competitive advantage and deliver value to a firm, it must be strategic and simultaneously demonstrate “VRIN” attributes. VRIN refers to Valuable, Rare, Inimitable and Non-substitutable (Burton-Taylor, 2004). Firms often sustain a competitive edge through their resources which are rarely available, not substitutable and imperfectly imitable (Mahoney and Pandian, 1992). The sustainability of the competitive advantage relies primarily on the barrier to imitation, also referred to as isolating mechanisms. Mahoney and Pandian (1992) summarised the isolating mechanisms for RVB as follows: (1) unique management talent that is inimitable, (2) resources with limited strategic substitutability by equivalent assets, (3) distinctive competencies and core competencies that are difficult to replicate, (4) corporate culture that is valuable, rare and imperfectly imitable due to social complexity, tacit dimension and path dependency, (5) culture that is as a result of human action and not of human design, (6) invisible assets that are by nature difficult to imitate, (7) valuable heuristics and processes that are not easily imitated, and (8) the time compression diseconomies and response lags.

The authors mentioned above further outlined organisational and industrial isolating mechanisms, which include: (1) unique historical conditions in which firm-specific skills and resources combinations result in path dependencies and heterogeneity over time, (2) organisational capital, reputation and image, (3) firms specific knowledge of buyers, sellers and workers capability, (4) learning and experience curve advantages that are kept as proprietary, (5) investment that entails high exit barrier and high switching cost and (6) the legal restrictions on entry. Therefore, performance improvement systems such as lean, TQM and Six Sigma, all have the resource-based view theory intricacies, which leads to process efficiency and effectiveness improvements (Helfat and Peteraf, 2003, Peteraf and Barney, 2003, Burton-Taylor, 2004, Terziovski, 2010).

3.3 Literature Review

This section deliberates on a critical literature review on manufacturing performance improvement systems employed globally over the years. Emphasis is then put on the lean manufacturing philosophy, its history and fundamental concepts for productivity and efficiency improvements in different industries across the globe.

3.3.1 Literature Review Process

Hofstee (2006) suggested that a researcher may carry out a literature review using a funnel approach where theories on broad but relevant concepts are reviewed, then the concepts are then screened and developed into the most appropriate central research concept. Therefore, the study began reviewing the literature on the broad techniques or tools used to improve efficiency and productivity in manufacturing industries by searching for relevant scholarly articles on academic search engines like Google Scholar, Ebscohost, and Emerald databases. To ensure the quality of articles, only peer-reviewed academic journal articles were included. The terms that were used in searching included "efficiency and productivity improvement techniques in the sugar factories", "Lean manufacturing", and "Lean frameworks in Mozambique". The related theoretical frameworks were developed for many decades thus, this research did not impose a strict publication period. However, fairly recent articles were considered, with most articles not older than ten years. Overall more than 60% of the articles used were published in the last decade. Finally, the forward snowball and backward snowball approach (Yadav et al., 2018a) was used to eliminate duplicity and to include all relevant papers

3.3.2 The Need for Manufacturing Strategies

As a result of the ever-changing business environments, manufacturers are hard-pressed to improve, optimise their operations and deliver new products in a short period (Karim, Arif-Uz-Zaman 2013). These business pressures call for a review of manufacturing strategies from time to time, and effective implementation of these strategies will play a critical role in the survival of many of these organisations. The manufacturing strategies seek to address product development speed, waste elimination, better process control, efficient human resources utilisation and manufacturing flexibility (James-Moore, Gibbons 1997, Allway, Corbett 2002, Papadopoulou, Özbayrak 2005, Karim et al. 2008).

Good strategies, when not well-executed, amount to nothing and only 10% of the well-formulated strategies are effectively executed (Judson 1991, Speculand 2006, Gurowitz 2007). Confirmation came from Mankins, Steele (2005a), who found that average organisations only deliver 63% of the financial performance forecasted by their strategies. In support of the rate of strategy implementation failures, Organisation (2007) found that 80% of the organisations have brilliant and suitable strategies, but only 14% of these organisations implemented them effectively. Therefore, results from the various studies confirm a general conclusion made by Raps (2004) that the actual success rate of strategy implementation in organisations is between 10% and 30%.

The failure of companies to implement their strategies leads to poor performance, negatively impacting countries' GDP. Effective strategy implementation is critical to sustained organisational and economic performances for organisations, then ultimately, nations. In supporting this view, Jooste and Fourie (2009) emphasise that several researchers noted that effective strategy implementation is a critical requirement for superior organisational performance.

3.3.3 Efficiency and Productivity Improvement Manufacturing Strategies

Manufacturing companies have implemented various measures to optimise efficiency and use production factors. Alkunsol et al. (2019) opine that any manufacturing organisation should efficiently utilise its equipment, inventory, and personnel. On the other hand, organisations should optimise their operations considering customer expectations, including product quality, price, product variety and producer's responsiveness (Raval et al., 2020). Researchers worldwide suggested various improvement strategies and techniques to satisfy these organisations' needs. Such strategies include TQM, lean and Six Sigma (Mandahawi et al., 2012).

During the nineties, TQM evolved as a typical management tool used by many manufacturing companies. Dahlgaard and Dahlgaard-Park (2006), Dahlgaard et al. (2008) define TQM as a company culture characterised by accumulated client satisfaction through continuous improvement in which all employees in the firm actively participate. Initially, Shiba et al. (1993) defined TQM as an evolving system of practices, tools and training methods for managing companies to provide client satisfaction in an exceedingly apace dynamic world. Hellsten and Klefsjö (2000) support the notion that TQM is dynamic. Hellsten and Klefsjö (2000) summarise Total Quality Management as an endlessly developing management system consisting of values, methodologies and techniques, and the objective is to raise external and internal customer agreement with a limited number of resources. Saxena and Rao (2019) noted that with customers' rigorous quality and competitors responding to such demands, the business turned to TQM as the key to reinforcing overall performance. Thus, although TQM improves productivity, it tends to focus on product quality while significantly ignoring production's efficiency.Therefore, TQM on its own is in adequate to holistically address efficiency issues affecting the sugar industry as it lack focus on increase of production.

In 1988, Motorola received the Malcolm Baldrige National Quality Award, which led to an augmented interest in six Sigma in alternative organisations (Pyzdek, 2001). Today, various organisations worldwide developed their own six sigma programmes which are currently established in nearly every business. Six Sigma is outlined as a business method enabling firms to drastically improve their bottom line. This improvement is achieved by coming up with and observing everyday business activities to minimise waste and resources while increasing client satisfaction by many its proponents (Magnusson et al., 2003). Six Sigma may even be delineated as an improvement programme for reducing variation that focuses on continuous and breakthrough enhancements. Improvement is driven in a very big selection of areas and at different levels of complexity, to scale back variation. The main idea of reducing disparity in a product or a service is to satisfy customers. The goal of Six Sigma is that solely 3.4 of a million customers should be unsatisfied (Magnusson et al., 2003).

TQM and Six Sigma focus on identifying process defects and improving product quality. On the other hand, lean has been an evolving overarching management tool that looks at various manufacturing facets, including resource utilisation, cross-functional synchrony, waste processes and human resources. Moreover, under TQM and Six Sigma, little attention was paid to removing redundant aspects of the processes that identify and remove non-value-adding activities. Chugani et al. (2017) posit that lean enables organisations to formulate more effective and inclusive strategies considering quality, operational and environmental dimensions.

Although various performance improvement systems are available, Naylor et al. (1999) stress that companies that have adopted lean methodologies outperform on cost than their counterparts implementing other approaches.Furthermore, Narasimhan et al. (2006) empirically established that organisations that adopted lean had higher cost performance than firms that adopted agile, TQM and the Six Sigma approaches. Based on this logic, it is reasonable to propose that the cost performance of lean adopters contributes to their performance capability (Vilkas et al., 2021).

A lean production system is a philosophy of manufacturing that combines Total Quality Management (TQM), Technology and Operations Management (TOM), Just In Time (JIT), Six Sigma, and Human Resources Management (HRM) (Netland and Powell, 2017). Researchers have argued that TQM is a more advanced form of Six Sigma and that there are many similarities among TQM, Six Sigma and lean, especially regarding origin, methodologies, tools and effects (Kumar et al., 2008, Andersson et al., 2006). The bundled practices are complementary and when implemented together, form a solid foundation for lean in an organisation (Furlan et al., 2011, Shah and Ward, 2003). Thus, the Lean manufacturing system or philosophy underpins this study, as a management tool to improve organisational efficiency and productivity.

3.3.4 Efficiency and Productivity in Sugar Factories

Generally, efficiency can be defined in operations management as doing a job well with minimum waste and resources (Heizer and Render, 2008). Bartuševičienė and Šakalytė (2013) define efficiency as a quantity that indicates a relationship between outputs to inputs. Several studies concede that it is tough to differentiate operational efficiency and productivity, as they are closely related and can be used interchangeably with higher productivity, leading to higher efficiency (Schoox, 2021, Bartuševičienė and Šakalytė, 2013).

In essence, improving efficiency means increasing output with the same input quantities. The following equation shows that a loss reduction leads to a higher efficiency measure.

Supporting this close relationship between efficiency and productivity, Toharisman and Triantarti (2016) established that the Indonesian sugar industry's lack of research and development resulted in low productivity and subsequently, low factory efficiency. Since both these performance measures are given by the ratio of unit outputs to unit inputs, they can be used interchangeably, and for this study, productivity and efficiency mean the same. The better the efficiency, the narrower the quantity difference between inputs and outputs, and the higher the efficiency ratio.

Efficiency in the sugar industry is defined differently by different authors. Peacock and Schorn (2002) view efficiency in the sugar factory as improving the Estimated Recoverable Crystal (ERC) while maintaining the same inputs. On the other hand, Malonza (2014) equated efficiency in a sugar factory to factory operational performance and defined efficiency as the quantity that measures factory operational performance. The main inputs for a sugar factory are sugar cane, labour, electricity, lime and water, while the main outputs are sugar and molasses. The same authors add that this factory efficiency is mainly affected by operational losses. Khan et al. (2019) estimate that up to about twenty per cent of recoverable sugar or sucrose is lost due to inefficiencies of sugar factories' operations and processes.

Sugar factories aim to convert the sucrose in the cane into sugar crystals, and the process of conversion or recovery of sucrose from cane has losses (Peacock and Schorn, 2002). The same authors define and group these as sucrose losses through bagasse, filter cake, final molasses and undetermined losses. Gunawan et al. (2018) contend that OR (overall recovery) is the main parameter measuring or quantifying the sugar factory efficiency, and it is mainly composed of ME (milling extraction and BHR (Boiling House Recovery). Overall recovery is similar to the cane-to-sugar ratio performance indicator as it consolidates two key performance indicators, extraction and Boiling House Recovery, to determine the quantity of sugar made from the amount of sugar cane processed (Gunawan et al., 2018). Cane to sugar ratio and overall recovery can be used interchangeably as they both measure the same operational efficiency of a sugar factory.

According to Bartuševičienė and Šakalytė (2013), efficiency is one of the critical perspectives that one can measure organisational performances and is used in many manufacturing industries, including sugar factories. Productivity and efficiency are the most commonly used methods to evaluate the success of any business operation or economy of a country, and an increase in productivity equates to improving efficiency (Heizer and Render, 2008).

Efficiency measurement in sugar industries is mainly done by comparing different sugar factories' efficiency parameters. It can be a comparison among several factories' performances using the statistical non-parametric data envelopment analysis method or using a best-in-industry factory performing factory as a benchmark. The outcome from the comparison, irrespective of which of the two options is chosen, forms what Gunawan et al. (2018) define as a gap analysis. Data envelopment analysis is a non-parametric production gap analysis tool that uses benchmarking to determine gaps in technical efficiency.

Islam (2015) used the data envelopment analysis to measure sugar factory efficiencies for all Bangladesh sugar factories and found a 3% efficiency improvement opportunity without input change. In their investigation of the efficiency of sugar factories of Uttar Predish, Singh and Agarwal (2006) used the data envelopment analysis approach to establish individual factory efficiencies and determine gaps and opportunities.

An efficiency gap analysis was conducted among farmers in sugar cane production in the Philippians by Padilla-Fernandez and Nuthall (2001) who employed the data envelopment analysis to benchmark the different operations. The most recent study by Gunawan et al. (2018) did an efficiency gap analysis for the Ngadirejo sugar mill using a Mauritian mill's 2013 operational efficiency performance as a single benchmark. Therefore, a single benchmarking gap analysis approach was adopted for this study.

Trying to improve the efficiency of Kenyan sugar factories after the expiry of preferential trade agreements for the COMESA countries, Wamalwa et al. (2014) studied the use of lean manufacturing techniques to improve the Overall Factory Efficiency performance at Mumias Sugar Factory. The authors further note that Factory Time Efficiency is a true reflection of overall factory operational efficiency.

Factory time efficiency measures a factory's capacity to operate without process or production stoppages (Ondiek and Kisombe, 2012). Lowering the factory time efficiency for a sugar factory will lead to a lower sugar output. Kustiyo and Arkeman (2019) concluded in their study of sugar factory performance improvements that the higher the equipment outages and production stoppages results in less sugar produced by a sugar factory. Therefore, enhanced efficiency for the sugar industry is beneficial for the industry's survival and sustenance by improving sugar output while holding inputs at the same level. Magesh (2019) emphasises that excellent sugar factories' performances positively correlate with overall recovery and factory time efficiency.

The study by Magesh (2019) also established that a unit standard deviation improvement in factory time efficiency results in a 0.519 of a unit standard deviation on a sugar mill's net profit in Tamil Nadu, India. The same study established that a unit standard deviation increase in recovery amounted to a 0.513 standard unit increase in the sugar mills' net profit. The gains in net profit result from improved factory efficiency as constituted by time efficiency and operational efficiency (recovery). Raw materials and labour productivity increase significantly when factories' technical efficiency is improved (Gunawan et al., 2018).

Studying the impact of efficiency in Kenyan farms, Maina et al. (2018) discovered that the cost of production was reduced by 8.7% without a change in inputs, but by improving the efficiencies of dairy farming processes. Concurring with these study outcomes, Magati (2012) confirmed that factory efficiency increases sugar factories' profitability, giving them a competitive edge in the global marketplace. Reduction in the cost of production improves the net profit of any organisation. As evidenced by various researchers, lean methodology improves efficiency by identifying and eliminating manufacturing waste in both continuous and discrete industries.

According to Gupta et al. (2020), efficiency is the most common method to measure overall organisational performance and top of measuring organisations' success metrics. With waste eliminated through lean manufacturing tools and principles, factory efficiency increases and eventually improves organisational financial performance as measured by net profit.

A study of efficiency among the sugar farmers in the Philippians (Padilla-Fernandez and Nuthall (2001) concluded that the more efficient a sugar farm is, the more profitable it becomes. Their study outcomes again cement the view that the sugar industry in Mozambique should look to efficiency improvements for their short and long-term survival strategic manoeuvres.

This study therefore relies on experts' views on the Mozambique sugar industry, in order to develop the most suitable key factory efficiency measures for this unique and critical industry. The definition adopted for this study is that efficiency is about maintaining or increasing sugar production within specification, using minimum or no change in input resources.

3.3.5 Efficiency and Productivity Challenges

Ever-increasing global market competitive pressures present untold survival and viability challenges to the manufacturing sector. Therefore, these organisations are making frantic efforts to counter these headwinds (Abdulmalek and Rajgopal, 2007, Al-Ashaab and Sobek, 2013, Krafcik, 1988, Ortiz, 2006, Taggart and Kienhöfer, 2013, Womack et al., 2007). Organisations are called to implement performance and efficiency improvement systems such as the lean manufacturing philosophy to respond to the ever-changing customer demands, meet tight delivery lead times and reduce quality defects and customer complaints.(Araújo et al., 2017).

Jasti and Kodali (2019) contend that both developed and developing countries' economies are characterised by unstable and fluctuating performances, making it difficult for industries to remain profitable and consistently meet their objectives. They were thereby threatening their very reason for existence. A study by Uhrin et al. (2019) noted that for manufacturers to survive in business, they need to manage the ever-changing diversity of environmental pressures exerted on their organisations to cope with the highly volatile business strategic requirements. The authors recommended that organisations adopt the lean philosophy as a management system to keep up with these variabilities of business environment.

According to Karim et al. (2011), organisations aim to produce customer products or services of required quality specifications, low cost and on time. According to them, these guarantee the success of any organisation's production or manufacturing system. Due to the increased pressure from the world's highly competitive markets, Belekoukias et al. (2014) also concede that it is now essential for the business to enhance operational efficiencies to reduce costs, improve costs product quality and reduce lead times. When organisations face a harsh economic environment, it is almost certain that they tend to trigger microwave, instant cost-cutting measures. Such actions include labour reduction, project cancellation and budget tightening. However, Rachman and Ratnayake (2019) argue that firms require more than instantaneous cost-cutting measures to survive these challenges. According to the above mentioned authors, the interventions include improving work efficiencies and productivity to maintain business profitability.

3.3.6 What is Lean?

Several authors vary in their definitions, but the central theme in these varying definitions is a common objective for lean practices: increasing efficiencies, reducing cost, improving quality and meeting customer demands. Mehta et al. (2012) view lean as a systematic waste identification and elimination method through continuous improvement philosophy. Naveen et al. (2018) define lean as a production method that aims to reduce expenditure while achieving targets, or be looked at as increasing efficiency through optimising flow while reducing waste and challenging the process status quo on how things are done. Oduoza (2008) indicates that lean is a system that seeks to improve operational efficiencies through integrating manufacturing best practices, which include continuous improvement, Just in time (JIT), total quality management (TQM), and resource planning and supply chain management (SCM). Lean is also defined as the application of a set of tools such as Value stream mapping, 5S, TPM, SMED and Six Sigma in manufacturing or production processes to improve quality, identify and eliminate waste, reduce production time and cost (Shah and Patel, 2018). According to Karim and Arif-Uz-Zaman (2013), lean is a philosophy that seeks to reduce waste and create a lean corporate culture. The philosophy considers the organisation with all its processes and comprises three core elements called lean principles which include the identification of value, waste elimination and smooth flow generation.

Lean philosophy is also defined as a production management system that enhances organisational competitiveness through reduced cost of production, improved product quality and shortened lead times (Sohal and Egglestone, 1994, Garza-Reyes et al., 2012). The same researchers contend that all the improvements in inefficiencies result from waste reduction and elimination that the lean package embodies. Jimmerson et al. (2005) view the lean philosophy as a system of operational and production management that continually seeks to eliminate waste, defects and always pursues perfection for organisational operations where it is implemented.

Wroblaski (2010) defines lean as a production practice that leads to increased manufacturing operation efficiencies through waste elimination and reduced manufacturing costs. The author further highlights that with a lean approach, defects are controlled in the organisational or manufacturing processes to try and minimise or eliminate waste due to defects.

Lean is an ideology that aims to reduce waste, implant continuous improvement and efficiency-enhancing practices, leading to lower production or manufacturing costs and therefore enhanced competitiveness of these firms employing the lean system (Johns, 2015). Bhasin (2012b) views the lean method as a business model that results in superior performance, giving the adopting firm a competitive edge by providing excellent value to shareholders, customers, society and employees alike.

Lean is a systematic approach that eliminates processing and operation wastes through systems automation and creates better processes that lead to high productivity (Maher and Denison (2018). Accordingly, Singh et al. (2018) define lean as a manufacturing management approach targeting waste elimination in the overall process to improve productivity. Yadav et al. (2018b) noted that manufacturing firms of various sizes and sectors began to adopt the lean methodology to remain competitive and stay afloat. Lean can also be viewed from a resource perspective; Bicheno and Holweg (2000) contend that lean is a production method that emphasises producing goods and services for customers with fewer resources such as energy, pollutionand materials. In view of this, the authors argue that it moves an organisation from the economies of scale mindset and way of doing business to the more effective and profitable economies of time.

Bruce and Jorge (1999) define lean as a concept that increases firm competitiveness through improved product and service quality. Also, they contend that this concept can be applied and implemented across different levels of organisations. At the same time, Keitany and Riwo-Abudho (2014) view lean as a means by which business models for organisations timely deliver quality products at a reduced cost. As organisations thrive on a global platform to meet the demand of the ever-changing customer needs, lean goes a long way in addressing the fundamental capabilities of these firms, thereby saving businesses from potential collapse and its effects on the economic and social well-being of the workers, communities and countries to which these firms belong and operate.

3.3.7 Lean Practice History and adoption by Industry

Post-World War 2, the Japanese automotive industry was hit the hardest, threatening its survival. Challenges faced included shortages of financial, human and material resources, among many others (Chahal and Narwal, 2017). The authors add that the said challenges led to developing and adopting the Toyota motor company's Toyota Production System (TPS) concept. According to Womack et al. (1991), this concept was adopted to achieve resource optimisation through production streamlining at Toyota. The TPS concept's main aim was to reduce waste and after its successes in Japan, it became known as lean. It was widely accepted as a means to increase efficiencies and waste reduction without additional resources (Bhamu et al., 2012, Vamsi Krishna Jasti and Kodali, 2014). In support of no additional resources, Chahal and Narwal (2017) defined lean as using fewer inputs to achieve the same outputs. Queiroz et al. (2015) add that the objectives and goals for adopting lean practices in the industry are to maximise production processes' efficiencies through waste elimination, quality improvement and shortened delivery time. Womack and Jones (2004) take lean as a philosophy that advocates using less of everything, leading to the reduction of waste while producing more with less. The core foundation on which the lean approach is built is streamlined production processes producing high-quality outputs with little or no waste (Karim and Arif-Uz-Zaman, 2013).

While investigating productivity improvement through lean practices, Shah and Patel (2018) acknowledge that a growing trend in the manufacturing industry is embracing lean techniques and philosophy to improve competitiveness by reducing production costs and process waste. This trend of increased practice adoption shall continue to grow for the foreseeable future as the manufacturing industry continues to be exposed to world economies and competitive forces. It is the observation and acknowledgement by Keitany and Riwo-Abudho (2014) that global competitive pressures exerted on organisations across different industries have led businesses mainly in the production sectors to relook, review and realign their strategies to keep in business, as well as gain a competitive advantage over rivals.

Naveen et al. (2018) reckon that many sectors have adopted the lean approach worldwide to become a universal production method in order to compete in the global economy. In support, Chiarini and Vagnoni (2015) argue that the wide use of lean principles and tools is due to its capacity to make organisations compete globally through waste elimination, which results in increased process efficiencies, reduced production costs, lead time and improved product quality. Many organisations have struggled to compete in the slowing global economic market and have adopted lean tools to stay competitive and survive (Esfandyari and Osman, 2010).

In trying to answer the big question of what an organisation should do to remain competitive and stay afloat, Yadav et al. (2018b) contend that manufacturing firms of various sizes and in different sectors began to adopt the lean methodology to meet product quality, reduce cost and eliminate waste. According to Esfandyari and Osman (2010), this method can be applied to any organisation and, if correctly used,yields positive outcomes in improved operational efficiencies, reduced production cost, and improved product or service quality.

In their research, Womack and Jones (1996) suggest that the primary premise on which the lean philosophy hinges and operates is to define customers' specifications, identify process value streams, enhance continuous value flow, demand pulls production approach, and strive for perfection. While Rachman and Ratnayake (2018) highlight five common elements of the lean system as found across literature, namely: reduction and elimination of waste in the processes of making goods or delivering services until the customer point, creation of a continuous flow of products in the manufacturing operations, reduction of inventory through implementing customer demand-pull production principle, achieve high-quality product or service based on the customer specifications, and process optimisation through application of systems approach.

Thurston and Ulmer (2016) refer to the lean system as the production system of the 21st century that is driven by safety, cost, quality, delivery and employee morale. This is the definition that is adopted for this study. According to Čiarnienė and Vienažindienė (2013), the words lean practice, lean enterprise, and lean production, are usually used interchangeably, or are commonly referred to as lean, which is defined as a bundle of tools or set of principles that evaluate the expenditure of resources against the value add for the end customer. When employed correctly, the authors reckon they will make business more competitive and profitable.

3.3.8 Types of Manufacturing Wastes

Naveen et al. (2018) define waste as anything outside of the minimum essential production requirements, such as the right amount of equipment, inventory and working time. Furthermore, Ruben et al. (2018) highlight that firms adopt lean to ensure consistent waste elimination and achieve environmental sustainability by establishing eco-friendly manufacturing processes.

Enshassi and Abu Zaiter (2014) postulate that occupational accidents and incidents lead to loss of operations production and employee productivity. Therefore, considering poor safety as a form of waste in the lean manufacturing model suffices. In their study, Ghosh and Young-Corbett (2009) established that safety and occupational incidents lead to increased nonvalue-adding activities in the processing chain and must be minimised or eliminated. Once again, this was in the context of the construction industry and developed country business environment. Some cost implications for poor safety include employee lost time, production loss time, compensation and high employee turnover (Nahmens and Ikuma, 2009). The authors argue that it is plausible to incorporate safety into production efficiency improvement plans or frameworks such as lean implementation. Bashir (2013) views that lean tools can be utilised to realise business safety objectives, making it appropriate for safety to be included in the lean implementation framework.

According to Womack and Jones (2004), this waste is referred to by the Japanese term ‘Muda’, referring to manufacturing or business processes and activities which do not add value to the final product. Liker and Lamb (2000) define waste in lean as any activity or process that adds to time and cost, but does not add any value that customers are willing to pay for. The author further suggests that this value-adding transformation involves physical transformation with an outcome or product per customer requirements and expectations in the case of manufacturing industries.

Lacerda et al. (2016) note that there are three different classes of activities in any manufacturing or industrial operations and business processes: firstly, those that add value to the final product and these activities must be retained, secondly those that do not add value but unavoidable and then lastly, the activities which do not add value at all and are avoidable, commonly known as type 2 Muda, and these must be eliminated.

According to Ismayil et al. (2019), the main objectives of the lean methodology are to reduce operational costs, improve product delivery time, reduce overproduction, reduce storage space, minimise inventory and ensure required quality. Parthasarathy et al. (2019) identify seven major lean wastes as defective products, inventory, time, motion, transportation, over-processing, overproduction, and all lean tools targeted to eliminate or reduce this waste, while preserving value for customers. Naveen et al. (2018) also note that there are seven lean wastes: motion, over-processing, correction, waiting, transportation, overproduction, inventory and knowledge. Concurring, Ohno (1988) professes that literature stipulates seven original wastes that emanate from the non-value adding activities as the ones identified, further categorising the wastes as follows:

- *Defects* – waste resulting from final products or outcomes from the manufacturing process not meeting their desired specification or failure to meet customer requirements. These products will be returned for scrapping or reprocessing, which ultimately leads to a high cost of manufacturing.

- *Inventory* – waste resulting from the unnecessary holding of raw materials or finished product inventory, leading to large sums of money being held up in inventories. Secondly, this results in colossal storage and handling costs as these large quantities of stock will require to be stored up and handled.
- *Motion* – any manufacturing setup requiring frequent workers' movement generates motion waste as the movements consume the workers' available productive time.
- *Over-processing* –waste generated from any organisational process that is 'nice' to have and does not add value to the final corporate or manufacturing outcome. Instead, it exposes the operations to potential increased chances of defects.
- *Overproduction* – any production that is more than the demand. Since the customers will not take up the goods, they will need to be handled, stored and above all, the cost for producing them will not be recovered until customers consume the goods.
- *Transportation* – some activities require transporting products and materials from point to point within the manufacturing setup. Transportation incurs fuel, maintenance and damaged parts costs, which need to be analysed to eliminate in some instances, while in others, to reduce significantly.
- *Waiting periods* – it costs the manufacturers money to have waiting periods in their processes for various reasons. These waiting periods do not add value to the customers. Hence, they are unwilling to pay for them.
- *Talent* - Liker and Meier (2006) added talent to this list of original seven types of wastes, and the authors' viewpoint is that if the human capital potential is not fully unlocked, this will result in lost input towards improvements opportunities that could have been derived from full utilisation of the human capital potential. One of the critical objectives of lean is to unlock employee creative potential by allowing employee participation in improvement initiatives (Ismayil et al., 2019).

Table 3-1: Eight Wastes in Lean Organisations

WASTE	DEFINITION
Over-processing	Final product or service exceeding customer specification
Transportation	Non-value-adding transportation activities within a facility
Inventory	Excess raw materials or final products
Wait time	Delays in the production lines
Defects	Making products or services not meeting customer specifications
Overproduction	Excess production of products or service
Motion	Unproductive and nonvalue-adding movement of people
Human Resources	Not fully utilising employee talents and overstaffed

Source: Researcher's compilation

Over many years, empirical evidence and literature have identified and confirmed these types of wastes summarised inTable 3-1(Womack and Jones, 1997, Ohno, 1988, Baker, 2003, Maclnnes, 2002).

3.3.9 Lean and Company Productivity

Due to internal and external pressures exerted on organisations, various academics and researchers agree on the need for a relook at production systems to seize growth opportunities. Concurring with this school of thought, the EU-Commission (2004) reported the urgent need for businesses to redesign and redefine their production systems to stand up and sustain the competitive rigours which businesses now face in the current global market environment.

To this end, Marchwinski (2004) pointed out a pressing need to identify and adopt practical methodologies and tools such as lean manufacturing, to assist the business in renewing its production and manufacturing business units. Also, Singh et al. (2018) suggest that companies are pressed to increase or maintain profitability due to the intensifying competition in the global markets without increasing product prices. The author adds that firms are looking at reducing cost and waste while improving efficiencies. This view shows a significant shift in efficiency improvement by the economy of scales and specialization to cost and waste focus to achieve performance improvements. Parthasarathy et al. (2019) contend that it is vital for manufacturing and processing companies to reduce cost, lead time and improve product quality to be competitive, and to this end, the use of lean principles and tools is the most appropriate approach.

Although initially invented in Japan, lean is now widely used in USA manufacturing industries to improve manufacturing and business performances (Pakdil et al., 2018). In support, many researchers have suggested that a lean system is a prerequisite to enhancing any manufacturing firm´s business performance and productivity (Piercy and Rich, 2015, Longoni and Cagliano, 2015). Generally, it is accepted and believed that the lean methodology is the most profitable concept (Jainury et al., 2012). Also, Jimmerson et al. (2005) view lean as a system that leads to waste elimination, improved product and enhanced operational efficiencies by applying operational innovations and fundamental industrial engineering principles. A review of company performances across different sectors showed that over a 10 to 15 period of analysis, the firms that adopted lean as a tool to improve organisational performances recorded significant productivity improvements, reduced waste, improved lead times, high customer satisfaction and reduced employee turnover (Liker, 1997, Womack and Jones, 1997).

The lean concept entails a continuous production flow of products and services, giving an organisation an edge as a time-based competitor (Bicheno and Holweg, 2000). The authors highlight and explain that improvements must be viewed and addressed three-dimensionally to meet this state of continuous flow: waste reduction, value enhancement and people involvement.

Iranmanesh et al. (2019) conducted survey research on 187 companies in Norway and established that lean improves organisational profitability through enhanced sustainable performance. Similarly, Rachman and Ratnayake (2019) concluded that the lean approach could be used to improve teams' organisation, supplier relationships, and operational and technical performances. Again, Sharma et al. (2016) opine that most firms adopt lean manufacturing methodology to reduce cost and improve quality, productivity and operational performance due to organisations' need to survive today's global economic challenges.

Further, Sisson and Elshennawy (2015) allude to the fact that lean leads to lowering costs and improving quality, and many manufacturing organisations are taking up the lean route and business strategy to grow and position their firms. Arbós (2002) concludes that implementing lean systems increases business competitiveness, timely product delivery, high-quality products, increased productivity and reduced inventories. A study by Swink et al. (2017) found that implementing lean practices leads to increased business profitability and reduced cost of production per unit. Ruben et al. (2018) established that lean has many benefits: including improved production efficiency, overall organisational performance, and many other sustainable benefits. Implementing lean practices increases equipment reliability, improved quality, and overall organisational performance (Womack et al., 2005, Chalice, 2005). Panwar et al. (2017) noted that some researchers had reported lean success stories in the continuous process industries. Several studies have supported the positive impact that the lean approach has on continuous processes context ,with Cook and Rogowski (1996) and Abdulmalek and Rajgopal (2007) concluding that there is a significant improvement in quality, lead times, and accuracy in demand forecasting after lean adoption in the continuous process environment. Continuous process manufacturing industry researchers found that adoptinglLean practices resulted in quality improvement, waste elimination, improved equipment availability and inventory reduction (Upadhye et al., 2010, Jiménez et al., 2012, Hodge et al., 2011).

Bhamu et al. (2012) studied the effects of implementing the selected lean tools in the Indian automotive manufacturing industry, and their study showed that the productivity and quality of an organisation could be improved through VSM (Value Stream Mapping), which is a lean tool. Several authors and researchers agree that the lean approach is the most appropriate tool for organisations seeking performance improvement at operational and business levels (Arya and Choudhary, 2015, Shah and Ward, 2007, Hines et al., 2004). Naveen et al. (2018) investigated the impact of different lean approaches. They concluded that a lean mindset for people working in the organisation is essential for organisations to realise the benefits of lean methodology, leading to improved efficiencies and high productivity. Karim and Arif-Uz-Zaman (2013) found that when lean tools are correctly applied, appropriate measuring matrices established and used, many manufacturing industries record improved performances and stabled lean culture in their organisations. Several other research studies confirmed a positive correlation between lean practices and manufacturing performances (Hallgren and Olhager, 2009, Flynn et al., 1995, Kannan and Tan, 2005, Rahman et al., 2010, Koufteros and Vonderembse, 1998, Shah and Ward, 2003).

Mehta et al. (2012) state that many organisations have adopted lean practices of varying sizes worldwide, which has resulted in colossal quality, production improvements, reduced operations waste, improved customer service, and most have turned the corner to profitability. There have been many studies, and empirical evidence supporting the fact that lean practices have a significant positive impact on key organisational performance indicators, including productivity, efficiency, profitability, return on investment, return on assets, and market share (Huson and Nanda, 1995, Callen et al., 2000, Fullerton and McWatters, 2001, Kinney and Wempe, 2002, Inman and Mehra, 1993, Eroglu and Hofer, 2011).

As a result of the reduced cost of production through waste elimination, improved lead time, high-quality products, and increased labour productivity, Womack and Jones (1996) noted that the lean approach has helped the manufacturing industry in a significant way to remain competitive in the global market. The impact and positive effects of the lean method are further evidenced in a survey on Australian manufacturing companies (Sohal and Egglestone (1994), which confirmed that for those organisations that adopted lean practices, there were increased lead times, improved labour productivity, production costs, and overall improved company performance. Similar lean results were observed in other studies (Panizzolo et al. (2012) Vinodh and Joy (2012), where inventory, labour, lead time, cost and overall operations productivity improved in both study instances.

A study on 187 Thai manufacturing companies by Rahman et al. (2010) established a strong positive correlation between lean practices and manufacturing performance. According to a survey done by Panwar et al. (2017), of the 121 Indian process industries surveyed, it was evident that implementing lean practices resulted in improved operational efficiencies and increased customer satisfaction. In their study, Shah and Ward (2003) established a strong positive correlation between lean practices and operational performances. This finding concurred with Womack et al. (2005), who found a positive impact on financial performance for all organisations that adopted and implemented lean practices. As a result of these performance benefits that lean has on manufacturing operations, Adamides et al. (2008) observe that most manufacturing industry organisations are increasingly adopting lean practices for their operations. A study by Chanegrih and Creusier (2016) concluded that there is a significant link between lean practices and competing priorities such as cost delivery, quality and flexibility. Therefore, from these findings, it can be deduced that if manufacturing organisations seek to compete and survive as businesses, they need to employ lean practices. According to Baldwin (2018), the regional EMS was forced to apply lean principles to cater to their customers increased product volumes. The author further notes that the introduction of the lean tenets resulted in reduced waiting time, improved quality, reduced defects and customer satisfaction. These operational changes meant that the layout and ergonomics changed, thereby making employees' movements and bending minimal, leading to positive employee behaviours. Godinho Filho (2017) attest to the fact that lean principles and tools are meant to reduce and eliminate wastes from manufacturing or business level operations and processes while improving productivity and efficiency of the firm.

Supporting the view that lean practices enhance productivity and performance, several studies concluded that there is a strong relationship between lean practices, such as increasing speed and efficiency of production processes and manufacturing performances of organisations (Shah et al., 2008, Sunder, 2013, Vinodh and Joy, 2012, Ward and Zhou, 2006). Furthermore, Cua et al. (2001) assert that lean practices enhance productivity and efficiency for manufacturing firms, while Naylor et al. (1999) contend that lean practices implementation leads to a positive effect on manufacturing costs, meaning the reduction in unit cost for outcome products from operational processes. Similarly, Gilson (2001) suggested that implementing lean practices and tools leads to firms improving their efficiencies, quality delivery time and reduced cost of production. As a result of the proven positive outcomes that lean has on manufacturing firms, there has been an increasing acceptance and adoption of lean practices by non-manufacturing industries as they thrive to improve their operations to survive (Stone, 2012, Esain et al., 2008, Baines et al., 2006, Ziskovsky and Ziskovsky, 2007, Paez et al., 2005).

Walter and Paladini (2019) postulate that implementing lean reduces operational waste, thereby reducing organisational operating costs, while increasing profitability. The authors further propound that the lean approach is a system that enhances efficiency, continuous process improvements and meets customers' quality requirements.

Several authors presented lean implementation benefits quantitatively, with Altekar (2005) asserting that if the lean system is implemented correctly, it will yield 80% waste reduction, cycle time reduces by 50%, the production cost is cut by 50%, a capacity increase of 50% and inventory cut by 80%, while production throughput remains the same or increased. In their study, Lathin and Mitchell (2001) concluded that by adopting the lean production methodology, organisations are set to reduce lead time by 90%, cost of quality cut by 90%, inventory reduction by 90%, and labour productivity registered a 50% increase. Keitany and Riwo-Abudho (2014) summarise the benefits for organisations that adopt and implement lean production systems by stating that there is no limit to the benefits accompanying lean implementation for firms.

3.3.10 Lean Principles and Tools

To implement lean, one needs to note different techniques identified in the literature to create a framework that suits the organisation's context. Bhasin (2012b) reckons that the lean methodology encompasses several principles and tools that are meant to enhance organisational performances. The lean principles are a set of five core principles used to build a systematic approach to manufacturing waste identification and elimination, and these principles are (1) customer value specification, (2) production flow improvement, (3) value stream identification, (4) the pursuit of perfection and (5) the use of pull mechanism (Karim & Arif-Uz-Zaman, 2013, Sousa et al., 2012, Jones & Womack, 2014, Singh et al., 2010, Hines & Taylor, 2000, Kilpatrick, 2003). If the lean principles are correctly employed, they manifest themselves in the manufacturing processes in various forms, including increased throughput times, reduced reworks rates, higher schedule stability, and improved manufacturing line uptime (Jina et al., 1997).

The term 'good manufacturing practices' can now be used interchangeably with lean manufacturing (Gollan et al., 2014). According to Zalatar and Siriban-Manalang (2018), globally, lean manufacturing principles and tools are gaining favour as a method for reducing waste, improving quality and increasing competitiveness for manufacturing firms. Shakoor et al. (2019) believe that the lean systems approach is significantly superior to the other performance and productivity-improving systems and models and has been widely adopted in the developed world, mainly in discreet manufacturing and service industries.

Bloom and Van Reenen (2007) conducted an extensive study on good manufacturing practices on 732 medium-sized manufacturing companies across Europe and the United States of America. The authorsconcluded that good operation management refers to those practices centred around applying advanced and Llean manufacturing techniques. Among these are Just-in-Time, Kanban (system of replenishment scheduling), 5S (cause and effect system), Enterprise Resource Planning which boosts efficiency, quality, and flexibility in manufacturing processes (Belekoukias et al., 2014, Bozer and Ciemnoczolowski, 2013).

The application oflean principles and its accompanying tools has resulted in several Indian firms improving their operations in many facets of their operations, such as reduced product returns, lowered defects by 50%, reduced production space by 17% to 45%, machine breakdowns reduced by about 60% to 100 % (Ferdousi and Ahmed, 2009). In their Indonesian garment industries study, Ferdousi and Ahmed (2009) found that those firms that adopted and employed lean principles and tools improved their performance. Poppendieck (2011) argues that lean principles have gone beyond being a universally accepted set of principles, but progressed to being recognised as a universally successful way of enhancing firms' performances.

3.3.11 Value Specification

Yamamoto (2007) accentuates that what determines a product or service value and quality is the customer in the marketplace, not the manufacturers or service providers. Furthermore, the author describes value as the difference between the cost incurred to buy a product and the benefits of owning that product. Also, Baumont de Oliveira et al. (2020) define customer value specification as customers' actual and hidden needs that the business exists to meet. They further emphasise that it is paramount to determine value based on its customer value proposition to become commercially viable. In agreement, Garver and Williams (2009) postulate that firms are getting market-oriented, placing customer value at the core of their processes. Value in lean philosophy completely understands customer requirements and expectations (Ahmed et al., 2020). Therefore, organisations must shift and align their value proposition to the customer requirements and expectations.

Customer's perception of value is critical in their buy or not to buy decisions. Therefore, various authors agree that it is imperative that businesses, including manufacturing entities, aim to satisfy their customers to be able to compete in the global markets (González-Reséndiz et al., 2018, Pérez-Domínguez et al., 2019). Suppose customers perceive that they are getting value at a fair price, in that case, they are likely to purchase and continue to do so for some time, leading to high customer retention, which is desirable for organisations. Therefore, quality or value specifications in the manufacturing businesses should be seen or defined from a customer perspective. To this end, Pattanaik and Sharma (2009) propose several ways to establish customer value specifications through customer engagements, interviews, surveys and web/online analytics. Also, Melton (2005) stresses that the point of departure in any business or manufacturing entity is establishing its value, as seen in customers' eyes.

Should customers complain, return goods or cancel orders, Baumont de Oliveira et al. (2020) advise that the business must make a great effort to establish the reasons behind any of these and correct them to remain competitive. Beatriz da Luz Peralta et al. (2020) assert that the customer value proposition is the cornerstone of innovation management in manufacturing enterprises. Omogbai and Salonitis (2016) emphasise that manufacturing entities' purpose is to create customer value. These assertions put customers at the forefront of all business product specifications.

3.3.12 Production Flow Improvement

For any production line to be more productive and efficient, the number of unplanned production stoppages, scrap and process product backflows must be eliminated at all costs. Minh et al. (2019) underscore that production flow refers to the material movements from one process to another. Sunjka and Murphy (2014) view flow as material movement from raw material to the customer, design to launch or order to delivery without waste, returns, or stoppages.

Baumont de Oliveira et al. (2020) reckon that at the core of lean manufacturing is creating a continuous flow of products or services from the point of order placement to the end of order delivery. As such, any form of production flow interruption results in order delays and leads to waste. Among many other customers' perceptions of value is the timely delivery of orders of products or services. Therefore, any delays due to stoppages of the production flows will negatively impact the customer satisfaction measure. Subsequently, the business bottom line goals, such as profitability and market share among many, are compromised.

Baumont de Oliveira et al. (2020)'s view is that debottlenecking production lines will go a long way in reducing the waste caused by production flow interruptions, since bottlenecking is a primary contributor to these flow interruptions. Rother and Shook (2003) further give some means of debottlenecking effectively to keep production flowing as the first in, first out principle, in conjunction with the one-piece flow methodology. Womack et al. (2005) acknowledge Takt time, total productive maintenance, root cause analysis, standardisation, visual control, and 5 'whys' as the primary tools employed to achieve organisations' lean flow principle.

3.3.13 Use of Pull Mechanism

The pull system is a concept that focuses on production scheduling based on customer orders (Minh et al., 2019). Accordingly, Liker and Rother (2011) concur by acknowledging that customer demand drives the pull principle of production, and customers get what they need when they want the products or services. The pull system helps organisations and manufacturing entities to eliminate or cut back on inventory waste by ensuring only goods on order are made and delivered to customers (Womack et al., 2005). Many warehousing storages and handling costs are avoided should manufacturing firms successfully implement the Llean pull principle in their operations.

In many ways, the pull concept has challenged the manufacturing industry's status core, where production was primarily driven by sales forecasts leading to very high handling and storage costs while waiting for customer orders (Kilpatrick, 2003). So essentially, the transition from a sales forecast position to demand manufactureyields positive results for the organisations adopting the lean pull customer demand-driven principle. Central to the pull system in the proceeding line or along the value streams, no material is passed to the next stage of operations before the work in progress of the preceding step is completed (Sunjka and Murphy, 2014).

Again, it is likely that firms will be pressed to invest more in customer-supplier relationships to align their production schedules while at the same time meeting the demand of customers. Rouke (2005) reasons that organisations use lean tools Kanban (a Japanese word for visual signal) and the JIT (Just in Time) to implement a lean pull system successfully. It is the submission by Heizer and Render (2008) that the lean pull concept enables the pulling of value stream materials in small batches, just as when needed in the system, thereby reducing waste in the form of inventory and defects.

3.3.14 Pursuit of Perfection

There is a missing route in many organisations: the route of doing work and continually improving the work done in the firms (Liker and Rother, 2011). The art and culture of doing the right things right the first time through employing the continuous improvement concept are, according to Prakash and Kumar (2011), the all-encompassing definition of perfection.

According to Ahmed (2018), pursuing perfection is a never-ending journey that organisations embark on to continuously improve their products or services. All this is to improve customer experience and value at a fair cost, while remaining profitable and competitive. Jones and Womack (2014) add that this state of perfection is an operational and strategic place with no waste in all the organisation's value streams. It is nearly impossible to eliminate all waste, as some of it results from necessary but non-value-adding activities, hence the need to continuously improve and strive for perfection. Sunjka and Murphy (2014) put it across as a principle that can be looked at twofold: relentless reflection into performances and continuous improvement of value streams. The authors further emphasise that continuous improvement, also known as kaizen, can be taken as small step improvement changes per time, resulting in a significant operational improvement.

Jones et al. (1999) stress that for any organisation employing the lean principle of pursuit of perfection of continuous improvement, emphasis must be placed on trust between management and employees. With this trust relationship, employees are free to identify improvement opportunities and be encouraged to bring them forward for discussions and adoption.

3.3.15 Value Stream Identification

Manufacturing and service firms undertake many activities and processes to develop products or services. Some of the tasks or processes add value, while others do not. According to Kang and Apte (2007), lean manufacturing systems' activities and processes are viewed as value streams. Sunjka and Murphy (2014) define the value stream as all processes and activities detrimental to producing the right product or service per customer requirements and expectations. Saboo et al. (2014) postulate that these activities constituting value streams begin from where the product manufacturing starts to finish.

According to most customers, the value can be categorised into lead time, product specification, performance and price (Lei, 2010). Value is also defined as specific actions and processes undertaken for any product or service outcome (Sunjka and Murphy, 2014). Those activities identified as not adding value to the customers and can be eliminated are known as non-value-adding activities or waste. The specific actions or activities needed to value stream are classified into three categories: physical transformation, problem-solving, and information management (Jones and Womack, 2014). These specific actions with categories will help establish processes and activities that add value and those that do not. The activities which do not add value are known as waste and must be eliminated or reduced.

Jones et al. (1999) confirm that value stream analysis (VSA) and value stream mapping (VSM) are the primary tools used to identify value streams within firms' operation processes or production lines for manufacturing enterprises. While these are two different tools, they help identify value and non-value-adding activities in any operations' value streams. The main output of value stream analysis is the identified waste, while value stream mapping goes further to give an operation's desired future state map. Further to underscoring the importance of lean principles, Shah and Patel (2018) opine that various lean tools can be used to effectively and successfully implement lean systems, thereby reducing waste and improving operational efficiencies. They further explain the lean tools or techniques in the following ways:

1 *Production Smoothing*: This technique helps eliminate overproduction through workload balancing across times, thereby producing smoothing and flexibility to the processes.
2 *Kanban* is a Japanese word meaning card or signal and gives visual information on the manufacturing floor. This tool controls the inventory through reorder levels and helps maintain the supply chain. This technique reduces waste resulting from stock.
3 *Overall equipment effectiveness (OEE)*: This tool measures lost production opportunities through equipment availability, efficiency and quality. For a manufacturing organisation without any waste, it is expected that this value will be 100%, meaning a perfect production system with no defects nor breakdowns and running at maximum speed.
4 *Total productive maintenance (TPM)*: This tool eliminates or reduces waste resulting from production equipment breakdowns and delays in manufacturing operations. Another aim achieved using this tool is to stop production losses due to defects and scrap. It can be said that the technique aids in process efficiencies and improved quality control. To achieve high levels of efficiencies, the TPM principle uses other sub-tools such as single-minute exchange of die (SMED), autonomous maintenance, 5S, safety, and quality maintenance (Rocha-Lona et al., 2013, Brah and Chong, 2004).
5 *Just in time (JIT):* with the Just in time tool, inventory wastes are reduced or eliminated as products are manufactured per order, and unnecessary spares or raw material inventories are not bought before they are needed. Therefore, the cost or waste resulting from excess raw materials is avoided. Secondly, storage costs for the finished products are also avoided if this tool is used correctly. Under the JIT principle

lies implementation tools such as Kanban, takt time, one-piece flow, visual control, levelled production, and multifunctional employees (Rocha-Lona et al., 2013, Kumar, 2010, McLachlin, 1997).

6 *Key Performance Indicator (KPI):* This tool is used as a guiding radar to ensure outputs from different suppliers' processes within the production system to customers are maintained within specific standard guidelines or specifications. Key performance indicators help manufacturing processes to focus on critical parameters within the whole manufacturing value chain, and any deviation will be spotted before the impact is cascaded downstream, causing other wastes in the form of scrap and efficiencies.

Panwar et al. (2017) note that many critical lean techniques and principles keep coming out from lean implementation literature. Some of them are Human resource management, total quality management, quick change over techniques, just-in-time (JIT), statistical process control, supplier partnership, continuous improvement, quality management, total productive maintenance (TPM), standard operating procedures, set-up reduction, and Kanban.

To successfully implement a lean strategy, there is a need to identify and apply different lean tools. According to Acharya (2011), these tools include Kaizen, Cellular manufacturing, total productive maintenance, value stream mapping, standardisation of work, and single-minute die exchange. Rother and Shook (1999) add that value stream mapping is crucial for identifying all kinds of waste and provides the much-needed link between information and material flow.

3.3.16 Value Stream Mapping (VSM)

VSM is a lean tool developed and intended to help reconfiguration, identifying improvement opportunities of production systems for organisations (Rother and Shook, 1998, Pavnaskar et al., 2003, Womack and Jones, 1996). VSM is a method to identify value-adding and nonvalue-adding activities in a process (Singh et al., 2018). It involves mapping a current state map, spot improvement opportunities using the five-whys tool, and incorporating them into the future map using lean tools such as the 5S, pull, cellular, training, kaizen, SMED, and continuous flow. Several authors note that value stream mapping (VSM) is the appropriate and suitable lean tool to reorganise and renew production to make manufacturing organisations competitive through increased efficiencies. Ramesh et al. (2008) expressed that VSM is not only a tool to identify, demonstrate and reduce waste, but also a crucial communication tool for strategic planning and change management.The authors further allude to the fact that VSM is now a commonly used tool for most organisations and businesses to plan and implement lean transformation strategies. Pavnaskar et al. (2003) view VSM as a lean method employed to identify waste generated from operational inefficiencies, and Rocha-Lona et al. (2013) contend that to analyse these inefficiencies, organisations will have to use both current and future value stream maps.

Parthasarathy et al. (2019) contend that the VSM tool is used to identify the impact of manufacturing operations on the environment and society. In their research, Nallusamy and Ahamed (2017) established that VSM is vital in determining types of manufacturing wastes and means to reduce or eliminate them. Similarly, when applied to any organisation, value stream mapping assists in making small but continuous improvements aiding the overall organisational performance (Rohac and Januska, 2015). In support, Parthasarathy et al. (2019) profess that the lean approach is generally a system mainly based on the pursuit of continuous improvement by eliminating non-value-adding activities in any organisation.

Rother and Shook (1998) explain VSM as a process employed to increase efficiency by identifying waste and eliminating waste by applying lean principles. The authors further note that the VSM tool comprises five distinct but related phases: product selection, current state mapping, future state mapping, work planning, and implementation. VSM is a lean tool that provides a solid foundation for production line and process improvements anchored on a comprehensive understanding of operations activities and processes by giving an overview of graphical process material and information flows (Langstrand, 2016). When VSM was implemented for banking operations, according to Bakri (2019), it was a potent and reliable tool that achieved high customer and employee satisfaction.

3.3.17 Lean: an Efficiency and Productivity Improvement Tool

As global competition intensifies, firms seek to compete to stay in business.Acharya (2011) recognises that lean tools offer manufacturing firms competitive advantages through improved efficiency, timely deliveries, quality, flexibility and reduced costs. This cost reduction is achieved through adapting manufacturing processes to do more with fewer resources such as time, costs, space and human capital, while maintaining the same quality or even better that customers are willing to pay for (Chen et al., 2006).

Primo et al. (2021) acknowledge that while lean manufacturing is the most common operational performance improvement system of manufacturing enterprises, its constructs are not well understood for successful implementation. According to Buys and Oosthuizen (2021), the automotive industry faces a highly competitive operating environment and the sector has successfully adopted the lean manufacturing methodology to improve operational efficiencies and cost management through waste reduction.

According to Womack et al. (2005) a lean methodology is an approach that focuses on improving operational production efficiencies through waste identification and elimination of non-value-adding activities on the production and process lines in manufacturing organisations. In their study, Iqbal et al. (2020) established a strong positive correlation between implementing lean methodology and organisational performances.

Several organisations that adopted the lean methodology have registered dramatic business turnaround success stories worldwide (Karim et al., 2011). Equally, Kovács (2012) views the lean approach as a performance-based process of choice for organisations seeking to leverage and increase their competitive advantage in the marketplace. Within New Zealand manufacturing industries, Tortorella et al. (2020) observed that lean practices such as waste elimination, cost reduction, and many others are employed to improve firm performances.

Chua et al. (2010) allude to the fact that lean reduces waste by eliminating inefficient processes, while improving value on those activities that customers are willing to pay for. Sisson and Elshennawy (2015) emphasise that lean is a business philosophy that enhances productivity and efficiency through waste reduction and focuses only on value-adding activities. Similarly, Karim et al. (2011) add that any manufacturing and processing industry's worst enemy is waste. Lean identifies and measures waste, and then provides tools to reduce or eliminate it.

There are several manufacturing philosophies researched and adopted by manufacturers in a bid to improve the firms’ competitiveness, and these include TQM (Total Quality Management), TPM (Total Productive Maintenance), and lean methodology (Mehta et al., 2012). The authors further noted that of all these different approaches, lean is the best system recommended for manufacturing firms seeking to reduce production costs and increase competitiveness in the global marketplace.

Furthermore, Papadopoulou and Özbayrak (2005) contend that all old and newly developed philosophies are benchmarked to the lean system. Similarly, Belekoukias et al. (2014) concluded that the lean system stands out among many other business strategies that improve production efficiencies and successful organisational turnaround. As a result, lean has become a subject of constant discussion among researchers. This gives the lean concept a privileged position as a point of success reference to be used on both the old and newly created approaches. Various authors and researchers alike concur that lean philosophy is the best management approach and practices for the 21st century and beyond (Dankbaar, 1997, Papadopoulou and Özbayrak, 2005).

Nawanir et al. (2018) contend that as manufacturing firms compete with other global manufacturing organisations, the adoption and application of lean tools and practices have increased, enhancing firms’ global competitiveness. Garza-Reyes et al. (2012) assert that manufacturing organisations have mainly adopted lean techniques and principles to gain an edge over competitors and increase market share in the ever-increasing competitive global market.

Lean practices result in performance improvements in operations and business, leading to organisations' competitive edge and profitability. Several organisations have adopted lean practices for the past few decades, thus Bilagi and Vasanthakumara (2017) contend that fundamentally, lean implementation results in superior quality products and reduced cost, thereby improving society’s standards of living. The authors further note that these outcomes are because with the lean approach, waste is wholly eliminated, quality is built into the processes, costs are reduced, and productivity improved, leading to lean culture within corporates. The ever-increasing requirement for the business to keep up with the ever-shifting market competitive pressures and customer needs can primarily be addressed through lean management practices (Chiarini, 2014, Chay et al., 2015). With the ever-shifting market demands and increasing competition, Satolo et al. (2017) assert that organisations are forced to continually improve on cost, lead time and quality, as they seek economic advantage and greater access to global markets.

Several research outcomes have confirmed that lean practices have been increasingly adopted in developing countries such as India and China in the past years. This acceptance is mainly due to industries looking to change their traditional manufacturing approaches to a more valuable and profitable lean way (Panizzolo et al., 2012).

3.3.18 Critical Success Factors for Lean Implementation

Lean manufacturing philosophy aims to eliminate non-value-adding activities within production processes through standardisation, improved setup times, better inventory management, and employee participation (Chavez et al., 2015). Several authors support this submission and further add that this multi-dimensional improvement positively impacts production reliability, lead time, cost, product quality and flexibility (Primo et al., 2021). Implementing a lean manufacturing system is recommended to reduce inventory, enhance process efficiencies, eliminate waste and increase value to the customer by improving output and utilising an organisation's resources most effectively (Shah and Ward, 2007).

Various authors have coined and prescribed several tools that may be used to successfully implement lean manufacturing systems in different industries . Dora and Gellynck (2015) contend that the success or failure of lean philosophy in any other sector apart from discrete manufacturing is due to the sector contextual factors such as culture, processes and skills, among many others. Sloan et al. (2014) suggest a lean approach started and has mainly been modelled around discrete manufacturing industries.

Therefore, applying lean practices or strategies to other sectors, such as the continuous process industry, is not straightforward. For the lean methodology to yield positive results and improve performances and efficiencies in continuous industries, it has to be adapted to suit this type of sector with its processes. Shah and Ward (2003) acknowledge that successful lean practices implementation hinges on unique organisational characteristics. Therefore, there is a need for each manufacturing firm to identify appropriate tactical lean strategies or tools to apply to their organisation, and they can be different. In support, Marvel and Standridge (2009) suggest that incorrect application of lean tools will result in further organisational processes inefficiencies by wasting organisational resources and reducing employee confidence in the approach. Rachman and Ratnayake (2019) add that some lean tools and principles are more suitable and applicable in discrete industries due to the unique industry characteristics, these are not easily transferrable to the continuous process industries.

Not all lean implementation has been successful; some have failed. For effective lean implementation, Anvari et al. (2010) identified and proposed eleven success factor frameworks: skills, change, education, financial capabilities, leadership, problem solving, goals and objectives, continuous improvement, performance measures, and organisational culture. Nawanir et al. (2018) sum it up by saying that to realise the benefits of lean practices, an organisation needs to comprehensively implement the lean philosophy in terms of scope and content, rather than using the piecemeal approach. Jainury et al. (2012) concluded that implementation is multi-faceted and needs one manufacturing firm to toe a very fine line of integrating various lean tools and principles to make the methods effective. The authors note that lean implementation is usually transferrable across organisational and country boundaries from developed to least developed countries. However, Jimmerson et al. (2005) assert that for different contexts where implementation is effected, there is a need to fine-tune the lean tools used to suit the different organisational and country contexts.

Findings by Repenning and Sterman (2001) observed that most companies fail to realise full benefits from lean implementation due to how they adapt and employ the methodology, with most of the failing organisations treating Lean tools as uncoordinated piece-meals. Implementing lean is not a simple plug-and-play exercise, with Taleghani (2010) acknowledging in his findings that only about 10 % of the companies who have deployed lean to improve productivity have achieved full benefits. Similarly, Sohal and Egglestone (1994) concluded that only 10 % of all the organisations that adopted lean have correctly implemented the philosophy, leading to most efforts failing to yield significant results.

In their study of 60 SMEs in India, Vinodh and Joy (2012) concluded that lean management's role and strategies are critical drivers of any successful implementation. Netland (2016) adds that to achieve and enjoy the benefits of an effective lean manufacturing implementation, managers need to display commitment by getting involved in the processes and activities of lean practices. The implementation may be driven from the workshop floor up. However, Mann (2010) indicates that the chances for successful implementation with this approach are slim, as it will be challenging to get the commitment of senior management, which is essential to effective lean implementation. A study on the bottom-up approach to ean implementation carried out by Scherrer-Rathje et al. (2009) for a Swiss manufacturer concluded that implementation driven from the workshop floor upwards leads to a lack of top management support, organisational communication, team autonomy and outright lack of interest in lean.

R. Jadhav et al. (2014) identified twenty-four barriers in their study of lean manufacturing implementation. They further stated that successful lean implementation is not only a result of the appropriate application of lean strategies or practices, but another towering factor is top management involvement. Aurelio et al. (2011) indicate that lean implementation faces many challenges and barriers. For this reason, outside Japan, literature shows that there has been little success in lean implementation (Kadri, 2010). A survey on US firms (Mohanty et al. (2007) showed that although these firms have tried to copy the Toyota lean way, very few have been successful in their quest to do so, and those who managed, failed to sustain the organisational performance improvements realised at implementation.

There are many complex challenges that firms face when implementing lean manufacturing practices. Several studies noted that less than 10 % of UK manufacturing firms have been successful in implementing lean and achieving the benefits of this implementation (Camagu, 2010, Bhasin and Burcher, 2006b, Ransom, 2008, Atkinson, 2010, Sim and Rogers, 2008, Corboy and O'Corrbui, 1999). These struggles with lean implementation are again evidenced in developing economies such as India, with Singh et al. (2010) indicating that the majority of the manufacturing firms have failed to realise the successful implementation of lean.

Beitinger (2012) noted that five key success factors were used in implementing lean at Siemens Guadalajara facility.These success factors are job environment and satisfaction, motivating participation, demanding leadership responsibility, developing new behaviour patterns, and insisting on lean methods and tools. Through a comprehensive literature review, Nawanir et al. (2018) identified some factors that lead to successful lean manufacturing implementation: flexible resources, total productive maintenance, pull system, supplier networks, small-lot production, quick setups, cellular layouts, consistent production level and quality control.

On the factors affecting effective manufacturing strategy implementation, Cater and Pucko (2010) found that the most prevalent obstacle to successful strategy implementation is poor and inadequate leadership skills. As one example among many, Al-Ghamdi (1998a) reported that 75% of organisations lack appropriate leadership on implementation activities critical for effective strategy execution. Concurring, Kaplan, Norton (2005)'s study revealed that about 95% of employees in organisations are not aware of their organisations' strategies due to poor leadership rendering its implementation ineffective. McMackin and Flood (2019)'s studies concluded that most problems and failures of organisations are attributed to poor leadership, resulting in weak strategy implementation. Several researchers attributed the high strategy implementation failure rate squarely on the shoulders of company leadership (Jooste and Fourie, 2009).

An extensive literature review shows that the key to successful lean implementation involves several factors that must be implemented and measured to ensure their presence in the system. These constructs are a good indication of practical implementation and can be used to measure Leanness. Yadav et al. (2018b) classify these constructs into management leanness, technology leanness, human capital leanness, process leanness, and customer leanness:

Management Leanness: For any successful change such as lean implementation, management willingness is required, and without it, it is impossible to implement lean. There are three factors under management leanness, that are identified,;

- Active management participation: This is a critical factor if the lean implementation is to succeed (Kumar et al., 2009, Emmitt et al., 2012, Panizzolo et al., 2012, Rose et al., 2014, Timans et al., 2014). This involves decision-making, seeking operational excellence, open-mindedness and enhanced communication with workers.
- Leadership: just as important as active management, leadership is paramount to successful lean implementation, as it provides guidance and vision to the workers (Achanga et al., 2006).
- Information flow: there must be smooth bidirectional information flow and open communication for the lean implementation to succeed. Vinodh and Chintha (2011) identified this construct as essential to lean implementation in an organisation.

Technology leanness: This entails increasing the rate of production by employing automation and flexible machines.

- Automation: according to Vinodh and Chintha (2011), manufacturing entities must employ machinery and minimise human interventions in processes to increase productivity.
- Machine flexibility leads to machine optimisation using a machine to make different products, thereby saving on space.

Human Capital Leanness: this means the effective application of human resources to achieve increased productivity and can be achieved through right-sizing, teamwork, commitment to work, and training and development of employees.

- Employee involvement: engaging employees through the lean journey leads to a successful implementation programme. Employees should be allowed to participate right from the beginning of the ean implementation processes and continually be engaged throughout the journey.

- Employee Multi-skilling: to achieve human capital leanness, employees must perform more than one function, thereby employing less workforce and eliminating possible manufacturing waste.
- Training and development: as technology and way of doing things evolve, the workforce must continue to skill upgrade and adapt to a more efficient way of doing activities or tasks. Several authors reckon that training and development of human capital needs to be ongoing within organisations (Kumar et al., 2009, Timans et al., 2014, Dora et al., 2013).
- Boyer (1996) ascertained that the key to successfully implementing the lean philosophy is a multi-skilled, responsible and well-trained employee base.

Process Leanness: With this construct, there is a massive process waste elimination through lean tools such as just-in-time flow, value stream mapping, 5S, visual management system, streaming of processes, levelled production, total preventive maintenance and continuous improvement.

- Value stream mapping is a tool employed to identify waste in a manufacturing or business process. According to Rawlins et al. (2012) and Popa et al. (2005), this process establishes the current state of affairs within an operation, establishing the efficiency and effectiveness of the current processes while unmasking potential improvement areas within the same processes. Romero et al. (2015) also emphasise that value stream mapping must be the initial step to be carried out when implementing the lean system.
- 5S: this refers to set, shine, sort, standardise and sustain. This tool, when implemented, reduces delays in the process activities. Gaiardelli et al. (2018) suggest that the lean 5S tool, when used, ensures workplace cleanliness, safety, and operation standardisation, among many other benefits and these constructs improve productivity for manufacturing firms.

- Just-In-Time: Karlsson and Åhlström (1996) state that just-in-time flow reduces in-process inventories, thereby eliminating waste due to unnecessary inventory, which takes up valuable and costly space.
- Streamlined Process: this helps achieve a sequential flow of materials in a process, while eliminating nonvalue-adding activities.
- Visual Management system: this is simple, straightforward, inexpensive, effective, and, therefore, Gunasekaran (1998) recommends it to organisations implementing lean. The system includes visualising processes, operating parameters, procedures, flow charts and safety instructions.
- Levelled Production: with production levelling, the production quantities will equal the demand quantities. This will help eliminate finished goods inventory wastes, i.e., tying cash resources to stock and cost of handling and space for storage.
- Total preventive maintenance involves routine production or manufacturing equipment maintenance to reduce unplanned production stoppages. Preventative maintenance also increases equipment life span, thereby reducing equipment replacement costs. Gunasekaran (1998) and Kumar et al. (2006) concur that total preventive maintenance is an easy and valuable tool for manufacturing organisations.
- Continuous Improvement is a system where organisations seek to continually do things or activities in a better and more efficient way to stay afloat in highly competitive global markets.

Customer Leanness: one of the key objectives of any business is to meet customer specifications and requirements. Therefore, to achieve customer leanness, there is a need for healthy and regular customer feedback on the quality of the product, delivery time, and after-sale support systems.

3.4 Empirical Literature Review

An empirical analysis of lean philosophy application in different industries and contexts is provided in this chapter. In the context covered thus far, we learned which sectors and countries have successfully applied it and which lack empirical evidence because they do not use it. The country context could be developed and developing countries, while the industry context encompasses discrete and continuous industry types

3.4.1 Existing Lean Implementation Models

A framework is a step-by-step roadmap to implementing a lean manufacturing methodology that helps businesses realise and unlock the value of applying an appropriate suite of lean tools (Ginn and Finn, 2007). Various authors note that a lean implementation framework is an established step-by-step roadmap to implementing a lean strategy (Al-Aomar, 2012, Banawi, 2013, Banawi and Bilec, 2014, Johansen and Walter, 2007, Lehman and Reiser, 2004). Sarhan et al. (2019) further opine that an implementation framework helps businesses to correctly apply lean tools to achieve improved performances and efficiencies through a step-by-step guide to lean implementation.

Again a framework is defined as a clear roadmap detailing steps undertaken by business processes to achieve their set goals (Van der Hoeven, 2014). According to Van der Hoeven (2014), these steps provide a solid critical link between an organisation's short and long-range objectives acting as the radar for the operations. In addition, Crabill et al. (2000a) suggest that manufacturing frameworks are essential tools to implement a performance improvement system by ensuring goals are matched with action plans.

AlManei et al. (2017) add that the step-by-step road maps are necessary for companies and industries to implement the lean strategy correctly and successfully in their firms. According to Crabill et al. (2000b), an implementation roadmap constitutes specific steps and stages one has to follow with the prescribed order of use in the lean implementation journey. However, several authors point out that a framework must be tailor-made for a specific industry due to its unique characteristics (Lathin and Mitchell, 2001, Standard and Davis, 1999). Alam et al. (2010) acknowledge that firms in different industries have different lean implementation roadmaps.

In line with Enshassi and Abu Zaiter (2014)´s view regarding lean implementation, it is imperative to remove uncertainties of which lean tools to apply, which ones are not applicable, and in what sequence these should be applied. An industry-specific lean implementation framework will go a long way in addressing these ambiguities and help guide industries to successful lean strategy application. Tortorella et al. (2020) reckon that while the existing lean implementation frameworks overcome some implementation barriers, the aforementioned authors noted that since meaning varies with varying environments and contexts, it suffices to accept that the actual lean implementation varies from organisation to organisation and from industry to industry.

Added to industry specificity, training on lean tools, stakeholder awareness, benefits, waste identification is key to any lean implementation framework (Wan and Chen, 2009). Similarly, Quarterman (2003) concurs that to initiate any lean roadmap, there is a need for comprehensive and targeted training on the lean constructs and tools for both leadership and employees. Various authors concluded that for a practical lean framework, training is the critical initial step to be undertaken by all stakeholders at multiple levels of employment (Singh, 1998, Wilson, 2009, Jordan and Michel, 2001, Crabill et al., 2000b, Hines and Taylore, 2006, Alukal, 2003, Lewis, 2004)

Crabill et al. (2000b) recommend that this lean pathway or framework have milestones and checkpoints that would require performance evaluation of the previous stages to ensure that the journey does not proceed without addressing elements or issues that may need to be addressed. This study shall refer these checkpoints to feedback loop controls as they help control issues that may arise during the journey as the operating environment changes.

Gao and Low (2014) developed a lean implementation model composed of the following steps or stages, philosophy, process, people, partners, and problem-solving. While this approach appears comprehensive, it lacks clarity on details of the desired step-by-step implementation model's, which's, and when's aspects. Besides, this 'Toyota Way Model' has been designed and developed in the construction industry context. The environment is unique and different from that of the sugar processing industry.

Through his study, Kowalski (1996) proposed a lean pathway or framework comprising ten steps that he named the Ford model. The framework emphasises work standardisation as the premise of a successful lean implementation. Primary lean tools and constructs covered by this model include reduced inventory, costs, focus on preventive maintenance, and JIT. Although this proposed framework covers most lean constructs, it misses the critical paths of training and provision of the feedback step required at various established checkpoints of the lean implementation journey.

activities. Furthermore, in the same study, Chahal and Narwal (2017) proposed six systematic steps toward effective lean implementation, shown below.

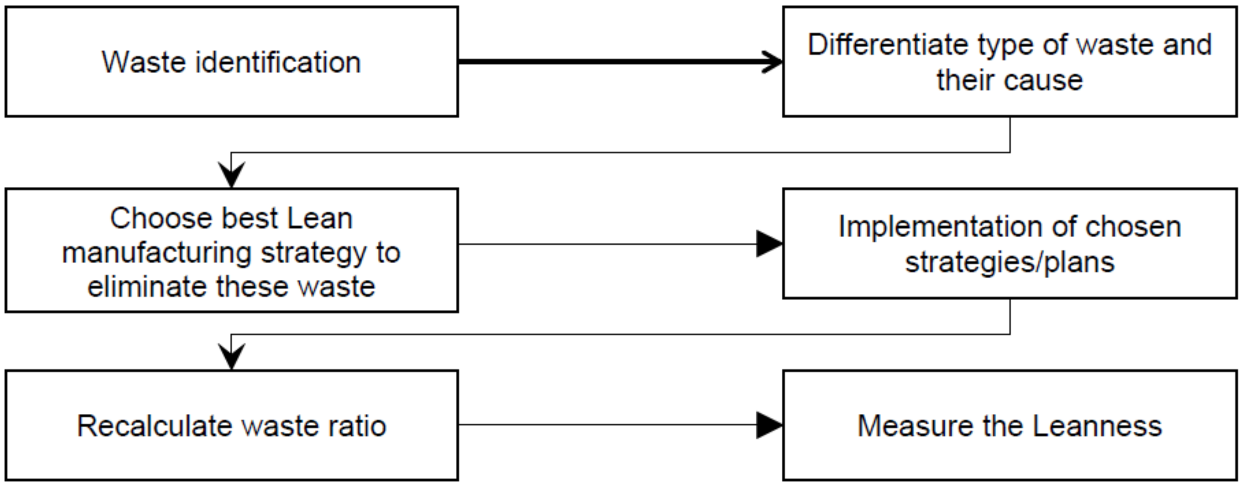

Figure 3-1: Effective Steps for Lean implementation

Source: Chahal & Narwal, (2017)

Lean implementation is a philosophy and, once implemented, should translate to a broad organisational culture of doing business. Although it goes a long way to address most of the key stages to successful implementation, this proposed six-stage implementation framework is silent on what is next after the last stage of leanness measurement. Also missing from this framework is the stakeholder buy-in exercise through teams' formal awareness and training before the waste identification stage.

Another ten steps in lean implementation framework were developed by Beck (2000). It is executed in the following sequence: inform production, waste reduction, production levelling, Kanban, Single Minute Die Exchange (SMDE), automation, sales planning and quality control. While this model addresses some of the lean implementation steps, several gaps are noticeable, such as the execution planning where identified wastes are individually matched to the lean tools that address each type of waste. Again, the model only mentions informing production, leaving out training and awareness of all stakeholders. A closer review of the framework exposes the lack of effort, achievement recognition and rewards, which is the fuel or energy behind the lean engine.

Vienazindiene and Ciarniene (2013) proposed an implementation framework where there is a need to begin by preparation for change that is strategising and getting buy-in from management, followed by identifying key success factors for lean implementation, and lastly, identifying appropriate lean tools that apply to the context of the organisation. The authors acknowledge that lean implementation has its challenges from the model, and hence lean implementation barriers were noted and incorporated into the framework. Highlighted within the framework also is the actual implementation stage, then lastly, the evaluation of leanness. This framework has ignored the feedback loop that helps with internal deviation controls, so successful implementation will be challenging to achieve without consistent assessments at different stages feeding back to the initial stages. Again, initial awareness and training have been omitted to ensure stakeholder buy-in and to guarantee the correct execution of the lean framework.

According to Hilbert (2009), lean implementation takes seven steps and is followed by the leading four bundle stages. Initially, a lean team is established, a vision is shared with all stakeholders, evaluation methodology is designed and agreed upon, develop a policy aligned and enables the vision, the stability of the current system is established, process redesign and problem-solving instituted were needed. Following these seven initial and preparatory steps on the lean pathway or framework are bundle stages: vision building, planning change, change management, recognising, and rewarding small gains. This model introduces the recognition, and the rewarding dimension of the framework missing from most frameworks developed so far. This enables sustenance of the lean journey through employee motivation and continuous monitoring and measurement, which is key to translating lfrom a mere set of tools to a way of doing business in organisations. However, this model is missing critical initial training, awareness, and stage feedback control, which are essential to sustain the framework's success.

Considering a five-stage implementation framework developed by Melton (2005), the author proposes data collection, analysis, redesign, implementation change, and measuring benefits. This frame provides a step-by-step guide to lean implementation, meeting the basic framework definition, but initial awareness and training are missing. This framework ignores the much-needed stakeholder buy-in, in any organisational change initiative. Although the framework correctly points to benefits measurement, the issue of recognition of achievement is not addressed, which is a driver to sustainable implementation of change.

To start the journey of lean implementation, Leisman (2015) suggested a three-step framework. These steps are needed to have a successful lean implementation journey and realise the goals and objectives. The framework developed by the authors mentioned above consists of the following steps: ask 'whys' five times to establish a root cause for process wastes, create a process map showing steps done by cross-functional team members, and develop a value stream mapping to identify unnecessary steps or processes aiding the increase in waste, while not adding value to the product or service from the customer perspective. While it addresses some of the significant steps that will lead to a successful implementation of a lean manufacturing strategy, this framework lacks detail on the critical initial step awareness and training required. Again, it has not been tested for applicability in any agribusiness sugar processing industry in a developing country.

It is noted by Setiyawan et al. (2019) that the various stages of sugar processing in most sugar factories have inherent inefficiencies and generate lots of processing waste. The authors acknowledged that lean manufacturing is the most widely used strategy to reduce waste. However, they then picked one tool VSM, to identify waste and made a recommendation. While the tool is mostly used to identify waste, it does not equate to the framework, which gives guided steps in their sequence to lean implementation. VSM is part of several tools that may be incorporated within an implementation framework. Secondly, the study referred to above was done in the construction industry and may not necessarily apply to sugar factories operating from an LDC.

Narayanamurthy et al. (2018) contend that to effectively implement the lean philosophy across an organisation, there is a need to have a way to identify the value stream so that waste can be correctly identified. This value stream identification entails eliminating avoidable tasks or activities within the process that lead to waste. The authors noted eight qualifiers for value stream identification through the literature review: autonomy, accessibility, associativity, alignment, affordability, achievability, acceptability, and assessable qualifiers.

In studying lean implementation in the plastic industry, Shah and Patel (2018) followed the following steps; identified appropriate lean tools applicable to the plastic industry, which help with waste reduction, and monitored efficiency and productivity improvements after implementing lean tools. Lastly, the authors compared past productivity figures against the new performances. The framework does not include reference points or steps for setting up key performance indicators and the basis for the same. Any success in implementation does not attract the recognition and reward to keep the wheels of the framework well oiled.

Also, coming up with a different implementation framework, AlManei et al. (2017) developed one with a three-stage approach: preparation, design and implementation. The authors explained that teams are built within the first stage of preparation, while training and finding a change agent occur. Value stream mapping takes place in the design stage to identify improvement opportunities. Lastly, for the implementation stage, AlManei et al. (2017) note that the process starts with a pilot project to sell the lean concept and perfect the implementation processes at this stage. Again, this framework is missing key performance indicators that are critical to the framework. Constant feedback is important for internal control networks, and the framework lacks a system to recognise and reward efforts.

Ismayil et al. (2019) postulate the lean methodology implementation framework as a 5-step cycle, and problem identification starts first using appropriate lean principles and tools. In the case of problem identification, value stream mapping is a suitable tool. At this stage, all wastes and improvement opportunities are identified. The second step in this proposed framework is to follow up on the identified problems and wastes from the previous step to analyse the root causes. The next step involves developing solutions to eliminate or reduce waste, formulated using the available lean principles and tools such as 5Y´s, automation, 5C, and many others. The fourth step involves the evaluation of the proposed solutions in terms of effectiveness and appropriateness. Lastly, this framework's fifth step involves implementing, standardisation and monitoring the applied tools and solutions. Once again, one of the key ingredients to sustaining any strategy is recognition of achievement, and this implementation framework does not cover this.

In their study, Allen and Robinson (2001) developed a three-stage lean implementation model, which starts with preparation, design and implementation. This framework covers the preparatory stages, including the critical, training and awareness steps, thereby setting up a good foundation for a successful lean implementation. However, this framework does not cover the other two important aspects, namely benchmarking in the preparatory stage and the continuous evaluation loop or feedback, to fine-tune the design stage along the implementation journey.

Sahoo and Yadav (2018) suggest that lean tools are more effective if applied in bundles and not as individual standalones. The same study recommended that firms seeking to implement lean tools need to identify as many tools as possible and bundle them for implementation to improve outcomes. This framework proposal is more mechanical-oriented, addressing operational level strategies while ignoring the equally important tactical and strategic level elements that an implementation framework should have. Also missing from this framework are key feedback, achievement recognition, and training and awareness.

Anvari et al. (2011) concluded that no two lean implementation frameworks are the same. The authors postulate that each framework is unique and applicable to a particular set of industry and environmental contexts. However, their observation was that there was a consensus among authors on the lean steps, pilot project, change planning, VSM, system analysis, lean awareness training, and implementation. However, Lewis (2000) argues that no two organisations can employ the same framework due to the inherent firm differences and the environment in which they operate. Wan and Chen (2006) support this view by recommending that different industries use different implementation templates to succeed in their individual, lean organisational journey. Leksic et al. (2020) concur with these views, acknowledging that much research on lean implementation road maps and frameworks produces general guidelines that are not universally applicable across industries, borders and continents. It is on this basis that this study proposed an industry specific lean implementation framework for sugar factories in developing countries.

3.4.2 Industry Adoption of Lean Manufacturing

In analysing the manufacturing process at Geosynthetics Industrial Works (GIW), Birchit (2021) established that the waste of waiting highly negatively impacted the management's cost reduction and containment measures. According to the same study, GIW's use of lean quality management systems reduced product defects and recalls, concluding that reducing waste in the processing system helped the company stay competitive.

According to Jasti and Kodali (2015), the manufacturing sectors face immense operating and viability pressures resulting from increased customer innovative demands and the emergence of new manufacturing philosophies replacing the old and existing methods. Bhasin and Burcher (2006a) suggested that these two headwinds faced by the manufacturing sector can be mitigated using lean manufacturing, resulting in significant reductions in inputs such as inventory tools, labour, raw materials, energy and space-maintaining or increasing output. The performance and improvement of manufacturing business processes can be achieved if enterprises adopt and correctly implement the lean manufacturing system across the breadth of their entire business (Dwivedi, 2020).

Rishi et al. (2021) contend that the Indian Small to Medium Enterprises (SMEs) play a huge role in creating employment and making a significant contribution to the Indian National GDP (GDP). The authors conducted a lean implementation assessment on four Indian SMEs to identify potential waste reduction opportunities. The study of the four SMEs in southern India concluded that Indian SMEs need to invest more time and resources in addressing and reducing waste in three significant areas: inventory, maintenance,and management, as these recorded the least per cent lean score across the four entities.

Göhner et al. (2017) noted that after Brazilian industries were affected negatively by the declining economy, many faced a colossal task of formulating stay-in business strategies to survive. The prevalent one among the many was adopting the lean manufacturing philosophy. Glaser-Segura et al. (2011) had earlier proposed that with the failing Brazillian economy, there were high prospects for the multinational companies, among many other companies, to adopt a lean manufacturing to hedge against the inevitable losses. After the implementation of the methodology by the multinationals operating in Brazil, it was found that most of them survived the headwinds brought about by the economic downturn experienced in that country (Göhner et al., 2017).

It has been proved that the lean implementation can enable future investment profitability estimates critical to making investment decisions. Varanchuk (2021) undertook a project on a Poland company to design and evaluate the improvements and estimating of project profitability after lean production system implementation. This project design was conducted to establish the viability of a future investment. The study concluded that the future implementation of thelLean methodology would improve the company's performance as measured by estimated future profitability.

In his study, Dwivedi (2020) identified three main performance improvements: Total Quality Management, Six Sigma, and Lean manufacturing system. Primo et al. (2021) submit that of the three performance improvement systems, lean has been more popular and has become the mainstream management approach due to its well-published results in the manufacturing industry. The adoption of lean manufacturing and its near-perfect implementation at Dell resulted in a 643.8% jump in the company share price from $20 to $148.75 per share within a year of adopting the methodology (Dwivedi, 2020). A study by Dwivedi (2020) attributes Dell's massive success to the correct and effective implementation of the lean philosophy.

In a study conducted by Chetthamrongchai and Jermsittiparsert (2019), the effects of lean manufacturing on the financial performance of pharmaceutical manufacturers were examined. The research concluded that implementing lean principles and tools positively correlated with the financial performance of pharmaceutical manufacturers.

In the face of multiple problems related to operations and profitability, a Jewellery company adopted lean manufacturing to resolve these issues. In a study on the impact of the lean intervention (Wieczorek (2021), significant productivity and efficiency improvements were observed and an increase in employee problem-solving skills.

Furthermore, the jewellery firm substantially improved quality performance, leading to increased profitability.

The wood and furniture business is a critical sector that contributes mainly to national employment, improving a country's socio-economic well-being. Abu et al. (2021) urge that to keep this vital industry afloat, the challenges to lean implementation must be identified and eliminated. The authors undertook a study to determine the challenges of lean implementation in the wood and furniture industry. They identified culture, knowledge, resources and human attitudes as the three main impediments to lean implementation. The study further emphasised that the organisation’s ability to mitigate the adverse effects of knowledge, culture, resources and human attitudes will determine the successful implementation of lean.

The lean manufacturing methodology was applied by Gherghea et al. (2021) to improve productivity and efficiency on Computer Numerical Control (CNC) machines, focusing on the Total Productive Maintenance (TPM) aspect of the lean system. Lean helped the firm to identify and reduce the waste of the wrong equipment operation, equipment breakdown and defects during the manufacturing process. The authors conclude in their study that the efficiency and productivity of the CNC machines improved significantly following the implementation of the TPM tool for lean manufacturing.

Zhu and Lin (2017) conducted an empirical analysis to establish the relationship between implementing lean manufacturing systems and firm value for Chinese firms. The study concluded that applying lean techniques has a strong positive impact on increasing firm value. Similarly, Elking et al. (2017) established that employing lean on organisations’ inventory management strategy yielded better financial performance for the adopting firms.

3.4.3 Methodology Used in prior Research

The advancement of lean research was mostly done through interpretivism philosophy and mostly case studies (Pearce and Pons, 2019). Jasti and Kodali (2015) found that 54% of research on lean was conceptual and descriptive thus, the remaining 46% was empirical. Of the empirical studies, half were on single in-depth case studies that provide a sound assessment of lean management. Thus, the lean body of knowledge was developed through a plethora of qualitative research and relied heavily on researcher subjectivity (Pearce and Pons, 2019). Myers (2019) asserts that qualitative case studies and related research methods interpret the complex nature of lean implementation; however, quantitative approaches should be utilised to achieve specific research benefits. Also, qualitative methods provide researchers with a rich contextual data source, which may not be the case with quantitative research.

Thus, qualitative empirical research has provided the much-needed contextual understanding. However, the weakness is that qualitative research is susceptible to subjectivity and calls for a more quantitative approach to researching lean implementation (Pearce and Pons, 2019). Studying lean implementation in Romanian enterprises, Marinescu and Toma (2008) successfully employed qualitative and quantitative research methodologies to meet the objectives of their study. Similarly, Van Dun et al. (2017) opted for a mixed-method approach in their empirical study to establish the values and behaviours required for effective lean management. Therefore, the literature shows that the most common research method utilised in lean manufacturing studies is the mixed method approach.

3.4.4 Lean Implementation in Mozambique

There is a worrisome absence of lean implementation for Mozambican firms, causing stagnation and even liquidation for some (Aga et al., 2021). The authors go further to note that because of a lack of management performance improving systems such as lean, Mozambican firms score way lower on firm capabilities of innovation, productivity and efficiency than their counterparts in the developing countries.

There is very little evidence of applying or adopting lean principles andmanufacturing philosophy among Mozambican industries, making them rank bottom in performance, as compared to their competitors in the region and developed and developing countries (Lemos and Scur, 2014). In a study on firm capabilities, Aga et al. (2019) found that manufacturing firms in Mozambique score particularly low when adopting systems for improving production processes. Firm capabilities are key productivity drivers in manufacturing organisations, which cannot be bought “off the shelf” (Sutton, 2012).

Furthermore, Aga et al. (2019) posit that weaker management practices currently implemented in Mozambique’s firms include a lack of lean manufacturing, limited development of talent mindset, lack of planning and targeting, and the limited use of documentation to capture lessons. Thus, this research is imperative in establishing a novel framework for implementing lean manufacturing in the Mozambican sugar factories.

3.5 Chapter Conclusion

It is evident from the discussion of the five main theories regarding efficiency and productivity systems that all of them, in their composite parts, contribute to the principles of lean manufacturing philosophy. For this reason, the study adopted all the discussed theories of efficiency improving systems as the underlying theories for building a lean implementation framework for the Mozambican sugar industry.

The section also covered a wide range of aspects of literature relevant to the study. Several percepts have been addressed and reviewed: definitions of lean, application of lean, lean waste and tools, and the five fundamental principles of lean. The impact of lean on efficiency improvements and critical success factors of its implementation were covered

Apart from the technical gaps within the frameworks reviewed, while many lean implementation frameworks are available in the literature, none of them has been developed for the sugar processing setting. Missing in the context of all frameworks reviewed is that none was developed in and for the LDCs setting such as Mozambique. The LDCs have a cultural, social, business, political, economic and environmental factors that differ from developed countries from which most models have been made to suit. This study therefore explores and brings the challenges and practicality of establishing such a framework in the Mozambican context to the fore. The next chapter provides the research method, design, tools and data analysis for this research.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 Overview

This chapter describes the research philosophy, method and designs, with details on how the primary and secondary data were selected and gathered for this study. The main objective of this research was to develop and evaluate a lean implementation framework to reduce waste in the sugar factories in Mozambique. To achieve this goal, the study made two broad pursuits, namely 1) critically reviewing lean manufacturing literature and consulting a team of experts in the Mozambique sugar factories to identify manufacturing wastes, establish key implementation success factors and then develop a suitable lean implementation framework to reduce waste and 2) to evaluate the suggested framework through a case study of the largest sugar processing company in Mozambique. Therefore, the research design section is presented in two main subsections, namely,

- Phase 1: methodology followed to develop the framework, and
- Phase 2: methodology followed to evaluate the framework.

The qualitative data for phase 1 of this study was based on the Delphi technique, while the quantitative data for phase 2 was based on an in-field framework evaluation at a sugar processing company in Mozambique. Secondary data on performance numbers were obtained from the production reports from the sugar factory.

4.2 Research Philosophy

A research philosophy refers to a set of beliefs and assumptions about developing knowledge, building new theory, or solving a problem for an organisation or industry (Saunders et al., 2009). Philosophical classifications of research include ontology, epistemology and axiology. Despite some common themes among the major proponents of these research paradigms, with varying emphasis and meaning, there appears to be no consensus on how to classify them (Mkansi and Acheampong, 2012). Research paradigms and approaches to research methods have been described, categorised and classified differently with an overlapping emphasis in several studies (Saunders et al., 2009, Lewis et al., 2003, Guba, 1990) and meaning.

Guba (1990) views positivism separately and differently from the other three paradigms, namely post-positivism, critical theory and constructivism. At the same time, Usher (2002) classifies the paradigms as positivism, interpretivism and critical theory. Again, Tashakkori et al. (1998) suggest four: logical positivism, post-positivism, pragmatism and constructivism. Lastly, Bryman (2004) only refer to the two main paradigms: interpretivism and positivism.

Table 4-1: Fundamental Beliefs of Research Paradigms in Social Sciences

	Research Paradigms			
Fundamental Beliefs	***Positivism (Naïve realism)***	***Post positivism (Critical Realism)***	***Interpretivism (Constructivism)***	***Pragmatism***
Ontology: the position on the nature of reality	External, objective, and independent of social actors	Objective. Exist independently of human thoughts and beliefs or knowledge of their existence but is interpreted through social conditioning (critical realist)	Socially constructed, subjective, may change, multiple	External, multiple, view chosen to achieve an answer to the research question best
Epistemology: the view on what constitutes acceptable knowledge	Only observable phenomena can provide credible data, facts. Focus on causality and law-like generalisations, reducing phenomena to simplest elements	Only observable phenomena can provide credible data, facts. Focus on explaining within a context or contexts	Subjective meanings and social phenomena. Focus upon the details of a situation, the reality behind these details, subjective meanings, and motivating actions	Either or both observable phenomena and subjective meanings can provide acceptable knowledge dependent upon the research question. Focus on practical applied research, integrating different perspectives to help interpret the data
Axiology: the role of values in research and the study's stance	Value-free and etic Research is undertaken in a value-free way. The study is independent of the data and maintains an objective stance	Value-laden and etic Research is value-laden; the study is biased by world views, cultural experiences, and upbringing	Value-bond and emic Research is value bond, and the study is part of what is being researched, cannot be separated and so will be subjective	Value-bond and etic-emic Values play a large role in interpreting the results, the study adopting both objective and subjective points of view
Research Methodology: the model behind the research process	Quantitative	Quantitative or qualitative	Qualitative	Quantitative and qualitative (mixed or multimethod design)

Source: (Saunders et al., 2009, Guba and Lincoln, 2005, Hallebone and Priest, 2008, Wahyuni, 2012)

Although there are some common themes in categorising the paradigms, various authors have different and overlapping views regarding classifying the research philosophies. Table 4-1 summarises research philosophies' fundamental beliefs and attributes.

4.2.1 Positivism

The positivists believe that true knowledge can be obtained by observing and experimenting with mother nature and as a result, scientific methods can produce knowledge (Kivunja and Kuyini, 2017). Essential features of positivism include the emphasis on neutrality, objectivity, measurement and validity (Madrigal and McClain, 2012, Campbell et al., 2012).

The positivist method employs a quantitative analysis method instead of the post-positivist one, which uses qualitative lenses to describe and analyse phenomena (Crossan, 2003). In addition, the positivist holds that scientific findings can be generalised over time and across contexts, just as their findings represent so-called truths about the world, regardless of the social, cultural, or historical context from which they originated (Lincoln et al., 2011). Dieronitou (2014) notes that positivists hold an ontological and epistemological view that an objective measurement or interpretation of truth can be achieved without human bias or other factors.

According to Rubin and Babbie (2005), positivists believe that the cause is ultimately responsible for the result. In addition, Lee (1991) asserts that positivism is mainly associated with inferential statistical, hypothesis testing, experimental and mathematical analysis.

4.2.2 Interpretivism

Qutoshi (2018) contends that phenomenology is both a constructivist and interpretive paradigm, taking philology and modelling methodology. Phenomenological studies examine people's experiences to discover what lies beneath and have been adopted in human sciences as a major philosophical idea and research method (Matua and Van Der Wal, 2015). Hermeneutic phenomenology interprets people's experiences, instead of the 'descriptive' nature of such experiences (Aagaard, 2017).

Furthermore, understanding the subject's lived experience in a detailed manner can be understood by applying an interpretive phenomenological analysis (Smith and Osborn, 2015). The interpretivists believe in the deep understanding of a concept and that knowledge is borne out of a subjective exploration of this understanding that involves interacting with the subject (Rahi, 2017). The phenomenological paradigm commits to examining the detail of each case in detail, before proceeding to the more general claims. It is an advantageous method to use when studying emotionally charged and often complex issues in nature. (Smith and Osborn, 2015). Generally, interpretivism is highly associated with qualitative studies seeking more profound insights into a phenomenon (Goldkuhl, 2012). Lee (1991) highlights that interpretivism or phenomenological approach has gained much ground in business research for several years now, as compared to the positivist approach.

4.2.3 Pragmatism

Pragmatism is a word derived from the Greek meaning action, practical or practice, and it is a research philosophy that embraces mixed-method research methodology to address research questions (Giacobbi et al., 2005). According to James (1907), pragmatism is a philosophy hinged on providing practical solutions to existing problems encountered by society. Likewise, Giacobbi et al. (2005) put it that pragmatism is a philosophy that focuses on the practical issues faced by the people, research questions postulated, and the research outcome.

With this philosophical view, knowledge is seen as contextual and is affected by political and historical factors. James (1907) equates pragmatism to objectivity and consensus through discourse and exchange between individuals and communities. Giacobbi et al. (2005) propose that with pragmatism, knowledge integrity or facts are tested and confirmed through dialogue, discussions, knowledge's impact and its practicality within the community.

Researchers who embrace pragmatic thinking evaluate research findings by looking at the practical, social and moral impact and relevance to society, avoiding philosophical assumptions, but instead focusing on the research question and the problem under study (Cherryholmes, 1992, Howe, 1988). Pragmatists usually employ one or more methods deemed pertinent to the specific research question being addressed, while considering the implications of their findings (Giacobbi et al., 2005). Thus, pragmatism uses the best research approach that addresses the specific research problem and objectives (Rahi, 2017).

In this study, knowledge and practical solutions to problems faced by organisations in a particular operating environment and context is being sought. The focus is on addressing the research problem to save the ailing industry without considering the philosophical underpinnings, making pragmatism an appropriate and suitable research philosophy for this study.

4.3 Research Design

A research design specifies how the study will be carried out, and there are three main types of research designs namely exploratory, explanatory, descriptive and experimental (Akhtar, 2016). Govender (2018) argues that there is no single definition or view on a research design; different authors present different definitions. Wilson (1992) views a research design as a set of instructions guiding the study of collecting, analysing and reporting data to answer a particular research problem. Babbie (2016) stipulates that research designs provide a framework for showing the relationship between data and theory. Bryman (2008) adds that selecting a research design mainly depends on the nature of the research problem.

For Bowers and Kuklinski (2021), a research design refers primarily to the methods and sequence in which data is collected, analysed and reported to accomplish credible study outcomes or results. According to Trochim (2006), a research design can be understood as the combination of measures, samples, treatments, programs, and methods of allocation to address the central research question. In addition, Ikeagwu (1998) postulates that a research design describes the approach to answering a research problem. Odoh and Chinedum (2014) submit that a research design refers to the methods used to collect, analyse, and interpret information to solve the problem investigated.

An appropriate research design must be employed to achieve the research objectives and align with the abovementioned methods. the exploratory sequential mixed method design advocated by Creswell et al. (2003) was deemed the most suitable pragmatic guide to achieve the objectives of the research process. For this study, qualitative data were collected and analysed, then quantitative data were collected and analysed. The findings from both approaches werethen combined in line with recommendations from (Rahnavardi et al., 2022) . Creswell et al. (2009) exploratory sequential mixed methods design was chosen for this study, mainly because of its apparent effectiveness and simplicity of implementation.

4.4 Research Approach

There are three different research approaches, mixed, qualitative and quantitative methods. Each has distinct procedures for collecting, analysing, interpreting, and reporting data in research studies (Creswell et al., 2006). A research approach specifies how the study will be carried out, and there are three main types of approaches to research: quantitative, qualitative, and mixed-methods (Bryman, 2008). The authors mentioned above further emphasise the need for robust and rigorous research designs to guide decisions that researchers make during a research study, by which they must make logical interpretations and findings.

4.4.1 Qualitative Approach

The qualitative research approach aims to discover traits, characteristics or qualities that cannot be easily reduced to numerical quantification (Leedy and Ormrod, 2015). Cook and Reichardt (1979) noted that qualitative methods are essentially concerned with the importance of understanding the respondent's viewpoint through interpretive analysis and rationale reasoning while observing and measuring the phenomena in their natural settings. In qualitative research, people's perception of events is observed and interpreted in a natural environment, taking a snapshot of people's perceptions (Khan, 2014).

The strengths of qualitative research methods are that they provide a realistic view of the existing phenomena, help understand complex situations, appreciate local and unique conditions and enable the extraction of information from primary and unstructured sources (Myers, 2019, Leedy and Ormrod, 2015). A standalone qualitative study would only achieve the study's objectives in part. Therefore, a qualitative mono-method approach didnot suit the analysis.

4.4.2 Quantitative Approach

Quantitative research is social research that employs empirical methods and statements (Sukamolson, 2007). In contrast, Creswell (2014b) defines it as a type of research that explains phenomena by collecting and analysing numerical data using mathematically based methods (in particular statistics).

Quantitative methods emphasise testing and verification by focusing on facts and reasons for social events, taking a logical and critical approach, including controlled measurements, objective outsider view, result-oriented, particularistic and analytical (Tuli, 2010). The purpose of quantitative research is to determine the world's objective reality, so rigid guidelines are very important when collecting and analysing data (Sukamolson, 2007). Sukamolson further adds that several types of quantitative research exist, including 1) survey research, 2) correlational research, 3) experimental research, and 4) causal-comparative research. Each type has its typical characteristics. Generally, this research approach begins with a specific theory, either proposed or previously developed, which leads to specific hypotheses that are then measured quantitatively, rigorously analysed and evaluated in accordance with established research procedures (Holton and Burnett, 2005). The strengths of quantitative research methods are that they produce objective and accurate non-biased results founded on well-established standards that can be replicated by other researchers (Watson, 2015). According to (Ali, 2021a), two significant advantages of a quantitative approach to a phenomenon are that it enables a researcher to categorise, summarise, and illustrate observations systematically. These are all known as descriptive statistics. The second advantage is that it allows researchers to understand and conclude a phenomenon (a sample) studied within a narrow, identified group of people.

A quantitative method uses two main types of statistical analysis, namely, 1) descriptive statistics-a type of quantitative data analysis that is used to provide a quantitative description of, or presentation of data, and 2) inferential statistics, which are inductive and allow researchers to generalise their findings from a sample to the whole population (Dan and Nigel, 2020). Additionally, Creswell (2013) argues that quantitative analysis can predict outcomes, while qualitative research can offer a greater appreciation for phenomena. A standalone quantitative study would only achieve the study's objectives in part. Therefore, a quantitative mono-method approach did not suit the analysis.

4.4.3 Characteristics for Quantitative and Qualitative Approaches

Characteristics of both approaches are required to achieve the research objectives. Initially, establishing specific waste for the sugar industry and building a framework needed the qualitative approach. Table 4-2 tabulates the characteristics of these two research approaches.

Table 4-2: Distinguishing Characteristics of Quantitative and Qualitative Approaches

	Quantitative Approach	Qualitative Approach
What is the purpose of the research?	To explain and predict	To describe and explain
	To confirm and validate	To explore and interpret
	To test Theory	To build theory
What is the nature of the research process?	Focused	Holistic
	Known variables	Unknown variables
	Establish guidelines	Flexible guidelines
	Predetermined methods	Emergent methods
	Somewhat context-free	Context-bound
	Detached view	Personal view
What are the data like, and how are they collected?	Numeric data	Textual and/or image-based data
	Representative, large sample	Informative, small sample
	Standardised instruments	Loosely structured or non-standardised observations and interviews
How are data analysed to determine their meaning	Statistical analysis	Search for themes and categories
	Stress on objectivity	Acknowledgement that analysis is subjective and potentially biased
	Deductive reasoning	Inductive reasoning
How are the findings communicated	Numbers	Words
	Statistics, aggregated data	Narratives, individual quotes
	Formal voice, scientific style	Personal voice, literary style

Source: Leedy & Ormrod, 2015.

Table 4-2 illustrates the similarities and differences between the qualitative and quantitative approaches with their applications. Leedy and Ormrod (2015) submits that qualitative and quantitative research provides a more robust understanding of phenomena when applied together than either research method alone.

4.4.4 Mixed-Method Research Approach

George (2022) states that the mixed methods approach answers research questions using both qualitative and quantitative research elements. It is argued that this research design can give a better picture of the study than traditional standalone quantitative or qualitative studies (George, 2022). Pragmatism underpins mixed methods research by allowing researchers to use a variety of approaches to answer research questions that cannot be resolved with one method alone (Doyle et al., 2009). As part of the mixed methods research process, pragmatism philosophical assumptions enable the mixing of qualitative and quantitative approaches (Hanson et al., 2005, Doyle et al., 2009).

Therefore, it is paramount for researchers who use mixed methods to correctly select the appropriate design types from among these four main types (Grech and Grech, 2021). According to Creswell et al. (2006), there are four main types of mixed methods: the triangulation design, the embedded design, the exploratory design and the explanatory design.

Triangulation Model: This design analyses human behaviour from more than one viewpoint to gain a deeper understanding of its richness and complexity and is popular in primary health care studies (Bulsara, 2015). As Bulsara (2015) points out, triangulation design has six fundamental characteristics: 1) It is frequently used in primary health care research, 2) Gathers data at the same time, 3) Integrates all data to clarify or better understand a problem, 4) Quantitative and qualitative data are treated equally, 5) Reports contain separate sections, and 6) Discussions bring the salient points together.

Data transformation model: The collected quantitative data types are converted into narratives capable of being analysed qualitatively, and/or the qualitative data types are converted into numerical codes amenable to statistical analysis (Tashakkori and Teddlie, 2010). Typically, this model is used for primary care studies in which quantitative data (survey) are obtained, while qualitative questions are asked to explore the results or to convert qualitative information into numerical codes that can be analysed statistically (Bulsara, 2015, Tashakkori and Teddlie, 2010).

Explanatory model: According to Bulsara (2015), this model consists of two phases. In the initial phase of the mixed method design, quantitative research questions or hypotheses will address the research question or issue, and then information from the first phase will be explored further in the second qualitative phase. The second phase of the explanatory model involves qualitative data further to analyse the quantitative results from the first phase for a better understanding.

The exploratory model: This design is also known as the sequential exploratory design and is composed of two phases, where the first phase, qualitative, helps develop the quantitative phase (Creswell, 2014a). According to Bulsara (2015), the two steps begin with qualitative and then move to quantitative design and testing. Doyle et al. (2009) postulate that this type of design is employed to develop and test research instruments (Instrument Development Model) or taxonomy can be developed (Taxonomy Development Model). Palinkas and Cooper (2017) add that the first phase's qualitative method is used to build or modify the conceptual framework or formulate questions for the quantitative survey in the second phase of the design. According to the authors mentioned above, the initial phase of this design will explore implementation steps and generate a conceptual model and testable hypothesis. A quantitative method is then used in the second phase to verify the model's validity. Palinkas and Cooper (2017) explain that the qualitative method of the first phase of this design uses interviews, group interviews, expert panel discussions, Delphi technique and may require several iterations before the model is finalised.

Several advantages are associated with exploratory designs, according to Creswell (2014a): 1) they are easy to describe, implement, and report because of their separate phases, 2) although qualitative aspects are typically emphasised in this design, including a quantitative component may make the qualitative approach more acceptable to quantitatively biased audiences, and 3) this design can be applied to both single studies and multiphase studies. Using this design, a researcher can develop and test an instrument if one is not yet available (Creswell, 1999, Creswell et al., 2004) or identify important variables to study quantitatively when the variables are not yet known (Creswell, 2014b).

After exploring several mixed-method approaches, the exploratory sequential mixed method design advocated by Creswell et al. (2003) was deemed the most suitable pragmatic guide to achieve the objectives of the research process. For this study, qualitative data were collected and analysed, then quantitative data were collected and analysed. The findings from both approaches werethen combined in line with recommendations from (Rahnavardi et al., 2022) . Creswell et al. (2009) exploratory sequential mixed methods design was chosen for this study, mainly because of its apparent effectiveness and simplicity of implementation. Table 4-3 illustrates the methodical sequence adopted for this study to answer the research questions.

Table 4-3: Research Methodology Map Adopted for this Study		
STUDY PHASE	**PROCEDURE**	**OUTCOME**
Qualitative data collection	• A panel of 5 experts chosen to participate in a Delphi technique iterations	• Interview recordings and transcripts
Qualitative data analysis	• Thematic analysis • Individual and within-group theme development • Use three round Delphi iterations	• Themes and thematic areas
Framework Development	• Review outcomes from qualitative data analysis to build framework constructs	• Lean implementation framework for Mozambique sugar industry
Quantitative data collection	• Deploy framework on a chosen Sugar factory to evaluate it • Survey	• Survey responses distributions
Quantitative data analysis	• Central tendency and inference statistics	• Survey statistics and estimates
Integration of qualitative & quantitative results	• Interpretation of qualitative and quantitative results	• Integrated discussions

The exploratory sequential mixed methods design adopted for this study consists of three stages following the guide by Grech and Grech (2021). The first stage is the qualitative phase, during which the problem is explored in depth and subsequently analysed. The second stage focuses on the qualitative analysis to use the information to analyse lean waste, identify efficiency measures, examine lean implementation success factors and ultimately construct a ean implementation framework for the Mozambican sugar industry. The third and final stage is the application of the lean implementation framework to the largest sugar manufacturer in Mozambique- evaluating and testing the framework, as well as to provide insights into the generalisability of the initial qualitative findings.

4.4.5 Phase 1 - Qualitative Study (Framework Development)

This subsection discusses the Delphi technique that was employed to develop the lean implementation framework. The primary data was sourced from the panel of experts, while the secondary data used in this section was obtained from production reports published on the South African Sugar Technologists' Association (SASTA) website.

4.4.5.1 The Delphi Process and Application

A Delphi survey strategy was employed to achieve the research objective’s part I of this study. Delphi was developed in the 1950's by two scientists at the RAND Corporation, namely Olaf Helmer and Norman Dalkey, as an iterative, consensus-building process for forecasting futures and generating scenarios (Fountis and Arunachalam, 2021). In consensus research, Jaam et al. (2021) note that the Delphi approach is the most commonly reported method which administers anonymous questionnaires over two to three rounds to reach a consensus among the panel of experts. Keeney et al. (2011) express the view that the Delphi method entails two or more questionnaires administered to a panel of experts. The iterations are repeated until consensus is reached or at the point of diminishing returns from the process (Campos-Luna et al., 2019).

The Delphi survey design is primarily qualitative, with its primary characteristics closely matching those of interpretivism, but provides a quantitative dimension depending on the problems being addressed (Vernon, 2009). Avella (2016) describes this design as gaining growing acceptance among dissertation research designs, especially among student qualitative researchers. Pchenitchnaia (2010) prescribes that the process of Delphi uses the qualitative approach to gather opinions from the selected participants on the panel of experts, and the quantitative method is employed to measure consensus on the collected views. For example, Mohr and Shelton (2017) gathered expert opinions through qualitative means and then used descriptive statistics to measure consensus among expert panellists; a score of 2 out of 3 was considered essential, while issues that scored below two were eliminated following the second round.

According to Ogolo (2013), a survey assesses people's opinions and behaviour made by asking them questions. Similarly, Odoh and Chinedum (2014) define a survey as a collection of distinct characteristics on how the information concerning the topic of study is compiled. The submission by Avella (2016) claims that Delphi surveys are used to gather the collective opinion of experts on a particular issue, and it relies on the concept that ‘aggregated intelligence’ improves individual judgment by capturing the collective opinion of a diverse group of experts.

Hsu and Sandford (2007) describe the Delphi technique as a process for gathering expert opinions to accomplish the meeting of sentiments on a specific real-life issue. The design is especially well suited to solving problems through a panel of experts, discussing action plans, or seeing causal connections where none previously existed, and it is more appropriate in areas like business and education studies (Avella, 2016). According to Hejblum et al. (2008), the Delphi method is usually used when studying areas lacking in research and in which collective subjective judgment could be more valuable.

Delphi survey designs have been successfully used in various industries and sectors to identify performance improvement practices (Gossler et al., 2019), project management (Chan et al., 2001, Gbededo and Liyanage, 2020), effective method used to set business goals (Wu et al., 2021), and information systems (Okoli and Pawlowski, 2004). It is described as an effective method that can be applied to achieve several objectives, such as identifying best operational practices, establishing priorities among options, and defining specific issues and concepts (Fletcher and Marchildon, 2014). Furthermore, surveys such as the Delphi technique are widely used in developing performance indicators, policy statements, and guidelines (Jaam et al., 2021)

According to Skulmoski et al. (2007), the Delphi survey design is also considered appropriate as a research instrument in areas of study where there is a lack of adequate information and literature about the problem or existing phenomenon. The Delphi survey design is primarily designed to provide further insight into topics with little or no knowledge, which are hard to define and highly specific to context and expertise or have future implications (Fletcher and Marchildon, 2014, Gbededo and Liyanage, 2020).

4.4.5.2 Make-Up of Delphi Panellist

Boulkedid et al. (2011) explain that the participants for the Delphi process share common interests but often hold different views on the same subject. Due to the diversity in views, the panel of experts may not reach 100% consensus, and researchers recommend a sample size between 5-50 experts per panel and a consensus measurement of between 55%-100% as acceptable when using the Delphi strategy (Birko et al., 2015, Vernon, 2009).

There is no random selection of participants with the Delphi survey design, the panel of experts is selected by adopting nonprobability methods, such as purposeful sampling or criterion sampling (Hasson et al., 2000a). Usually, an interest group is assembled to assess issues of common concern through correspondence or in-person to reach a consensus and make group decisions in various areas (Fountis and Arunachalam, 2021). In addition, Polit and Hungler (1995) emphasise that participants are selected to apply their knowledge to a research problem, and the assumption made with the purposive sampling is that the study has adequate knowledge about the population can be used to handpick the cases to be included in the sample.

Fountis and Arunachalam (2021) note that the Delphi process consists of seven iterative steps that are continuously repeated until a stable consensus or disagreement is reached on a subject; the steps are as follows:

1. Participants are asked to give their thoughts on a specific set of issues.
2. A facilitator creates a document capturing the group's response after analysing everyone’s comments.
3. The participants compare their responses with a normative response of the group to discuss them.
4. Discussions take place through face-to-face or remote communication to allow for challenging and enhancing the ideas of others.
5. Participants can then discuss the matter again anonymously, using a combination of previously learned.

6. The process is repeated, resulting in another group report. The process continues until a stable consensus or disagreement is reached.
7. At the moment of scoring, accuracy and independent opinion are crucial to make the process objective.

Skulmoski et al. (2007) asserted that a quality panel of experts in the Delphi technique should have experts with: i) adequate knowledge and experience in the topic under study; ii) capability and will to contribute: iii) enough time to participate in the Delphi technique; and iv) effective communication skills. The number of experts in the panel need not satisfy stringent statistical requirements but should be of adequate quality to ensure the reliability of the resultant expert opinion (Nordin et al., 2012). Further, the use of Delphi techniques in the L#lean manufacturing framework was supported by Nordin et al. (2012), who argued that using a panel of experts reduces one-person bias on a particular phenomenon, conducting a Delphi technique does not require meeting physically, which enables busy experts to participate easily. It was also deemed suitable and appropriate in the pandemic era, where in-person meetings were discouraged.

Different research studies have used the Delphi survey design for different purposes; the leading application is for purposes of:

- framework development for a variety of industrial and national contexts (Bacon and Fitzgerald, 2001, Holsapple and Joshi, 2002, Mulligan, 2002, Snyder et al., 2014, Xu et al., 2021)
- identifying success factors, as well as challenges of particular sectors or initiatives (Hayne and Pollard, 2000, Brancheau et al., 1996, Lai and Chung, 2002, Larsson and Wollin, 2020), and
- forecasting an industry, product, service, or research area's future trends (Czinkota and Ronkainen, 2005, Kendall et al., 1992, Viehland and Hughes, 2002, Zhang et al., 2021).

This research is in the sugar industry sector that is context and expertise specific. It seeks to identify performance improvement practices. At the same time, the need to select and prioritise among options. It is then appropriate for this study to employ the Delphi survey to identify lean waste, critical success factors, challenges and develop a suitable lean implementation framework.

4.4.5.3 Target Population

Population means all the cases from which the study draws their sample. Mozambique's sugar factories comprise four commercial companies, Xinavane, Mafambisse, Maragra, and Marromeu. According to Kegode (2015), Xinavane dominates sugar production in the country owing to its large sugar estates and milling facilities.

4.4.5.4 Sampling

The study cannot examine the entire population as they do not have the time or resources available, so they utilise sampling techniques to reduce the number of cases. (Taherdoost, 2016). There are two types of sampling techniques: probability sampling and nonprobability sampling, and researchers can generalise research findings from probability samples (Acharya et al., 2013).

In coming up with the panel of experts for the Delphi techniques, the study used purposive sampling to select experts with sound knowledge of the sugar processing industry. Experts who had knowledge on waste, strategy implementation, challenges, and manufacturing interventions to improve efficiency and productivity in the Mozambique sugar factories.

4.4.5.5 Criteria for Delphi Experts

In his study, Chedi (2011) suggests that the primary criterion for selecting experts for a Delphi study is that they should have deep knowledge of the subject under research. There are different opinions and submissions about the definition of an expert. Hasson et al. (2000a) mention that the dispute over when a professional becomes an ‘expert’ is one of the most divisive in the field. For Grisham (2009), an expert must have at least twenty years of practical experience working in the field or may have an advanced degree combined with at least twenty years of research, teaching, and publication, or a combination of both. Adding, McKenna (1994) defines an ‘expert’ as being a highly knowledgeable individual. Devault (2018) believes that an expert is someone who has extensive expertise and experience in the subject of the research. Providing a similar definition Goodman (1987) states that experts in the Delphi approach are advocates well informed about the subject under study.

Researchers should set the criteria or qualifications for the Delphi experts beforehand to prevent the panel's improper constitution (Andranovich, 1995). Each expert should have four fundamental expertise in order to qualify for a Delphi panel, and these are expertise about the issue being investigated; expertise about one’s capacity and willingness to participate; sufficient time allocated for the Delphi; and proficiency in communicating one’s findings or thoughts (Skulmoski et al., 2007, Adler and Ziglio, 1996).

In drawing up a procedure, panel sizing of the Delphi technique, the following essential characteristics as identified by various researchers (Dalkey, 2018, Landeta et al., 2011, Keller et al., 2012) was observed throughout this study:

1) Anonymity - By utilising other communication methods, such as questionnaires, in which expressed responses are not attributed to individuals, anonymity can be achieved.

2) Controlled feedback from the interaction - Panel interaction is a group discussion involving interactive discussion amongst participants, culminating in sharing the previous stage's results, during which each member is given a chance to reflect on their answers.

3) Statistical group response - In group decision making, a group response is generated by averaging the opinions of each member, with each member's opinion being included in the final group outcome.

4.4.5.6 Procedures for Selecting Delphi Experts

For Delphi technique, expert participation is paramount and is the cornerstone of the decision-making process. Therefore, a researcher must draft a procedure for the selection process (Chedi, 2011). In agreement, Helmer (1967) posits that a selection process of the Delphi panel of experts must follow a predetermined criterion for a panellist or expert qualification. Ametepey et al. (2019) caution that a procedure of selecting experts must be drawn and shall ensure that the pitfall of following the path of least resistance must be avoided.

For this research study, Ametepey et al. (2019) suggested procedure was adopted and used to build a panel of experts for the sugar industry in Mozambique. To qualify as a panellist in this study, each expert needed to meet five out of the following minimum requirements as recommended by Ametepey et al. (2019):

- *Residency:* The panellist should have lived in Mozambique for at least ten years.
- *Knowledge:* Has a minimum tertiary academic qualification of either National Diploma/B-Degree/Master's degree/PhD in any related field of study.
- *Experience:* Has a history of working in the Mozambique sugar industry at a senior level for a minimum of 10 years.
- *Employment:* Currently serves as supervisor or manager of establishment in the sugar industry in Mozambique, or has previously served in a professional or voluntary capacity, e.g., at the place of employment (an institution, business, agency, department, company) in the sugar industry in Mozambique.
- *Recognition:* Currently serves as supervisor or manager of establishment in the sugar industry in Mozambique. or has previously served in a professional or voluntary capacity, e.g., at the place of employment (an institution, business, agency, department, company) in the field of Mozambique sugar processing sector.
- *Research:* Has submitted a proposal or received research funding by a national, regional, or private source that helps the sugar industry in developing countries.
- Teaching: Has organized, prepared, and successfully presented one or more sugar processing and manufacturing training workshops focusing on the group for which expertise is sought; Membership: A member of a professional body or should be the representative of a professional body so that his or her views can be readily transferred to the population.
- *Willingness:* Participants must be willing to contribute fully to the entire Delphi study.

This study employed a purposive, non-random probability sampling method to pick the qualifying participants to constitute the panel of experts in line with the recommendation by Shariff (2015). By its name, purposeful sampling refers to the method of choosing a sample with a specific purpose in mind, usually one from the sample's population who is knowledgeable about the study issue (Polit and Hungler, 1995, Hasson et al., 2000a).

4.4.5.7 Determining the Panel Size

The number of experts who should be included in the panel is called panel size (Polit and Beck, 2008). A Delphi survey requires an expert-led approach rather than a more traditional quantitative approach. Because this calls for qualitative rather than quantitative considerations, the number of participants is expected to be much lower than for a standard quantitative survey (Ametepey et al., 2019). The subject of adequate panel size has been an issue of contention among many researchers and academics, with Shariff (2015) arguing that there is a lack of a clear guideline on the standard size of a panel of experts.

Needham and de Loë (1990) suggest that at least 10 and a maximum of 50 panellists are needed to get enough ideas, while this incurs excessive cost inefficiencies due to lengthy iterations. The research problem determines the size of a panel and whether the panel is homogeneous or heterogeneous by the required composition. de Villiers et al. (2005) further argue that 5-10 experts are enough for a panel composed of different professions, while 15-30 is considered appropriate for a panel from the same discipline.

Several other researchers have reported that 5 to 10 experts on a panel are a good number for a Delphi in-depth study, but in some cases, one can cap the number at 30 as a maximum (Turoff, 1970, Clayton, 1997, Cavalli-Sforza and Ortolano, 1984, Armstrong, 2006, Giannarou and Zervas, 2014). Therefore, for this study, the study ensured that the panel of experts represents a wider variety of backgrounds and levels of operations and experience, in line with what Rowe and Wright (2011) refer to as a guarantee of a broad base of experience and knowledge for the Delphi study. Also, for this study, a panel size recommendation of 5 within the range recommended by several researchers as noted above, was adopted to enable an in-depth analysis of the qualitative part of the area under investigation.

4.4.5.8 Data Collection

In qualitative research, a wide array of data collection methods can be employed to collect data in the form of field notes, interviews, documents, graphic representations, and recordings of naturally occurring interactions (Coffey and Atkinson, 1996). According to Tesch (2013), twenty-six methods exist to collect data for a qualitative study. Aborisade (2013) notes that the predominant data collection method for qualitative research is the interview method. Interaction with respondents and asking their opinions are integral to interviewing. The technique is usually used with questionnaires, historical archives, and other data collection methods for best outcomes (Soni and Kodali, 2011).

The interview method can further be classified into three types or categories of structured, semi-structured and unstructured interview types (Cooper et al., 2006). With the emergency of technology, Harrell and Bradley (2009) opined that e-mail interviews and audio-visuals such as Skype, Facebook, Zoom and Microsoft Teams have gained popularity and favoured alternatives to face-to-face interviews. This study employed a semi-structured interview method to gather data for the qualitative component of this research. Silverman (2013) states the semi-structured interview provides flexibility, and its open-ended questions ensure in-depth discussions on specific topics under investigation. Secondly, the interview method was chosen due to its advantages, as given by Creswell (2013), of high response rate and its ability to extract rich and comprehensive data, and lastly, it allows for detailed follow-up questions.

After conducting a comprehensive literature review, a semi-structured interview schedule was developed for this study, according to Sim et al. (2018)'s recommendations, and all the panellists were asked the same questions. The developed questions focused on addressing the key research questions, which are, 1) what are the waste in the sugar industry? 2) what are the sugar industry's critical success factors for a lean implementation framework? 3) What are the key efficiency and productivity measures for the sugar industry in Mozambique.? 4) which lean implementation framework is suitable for the sugar industry in Mozambique?

The data outcome from the semi-structured interviews was collated into themes, Lean waste type, critical success factor and efficiency measure, as well as challenges for the industry. After the interviews, a Delphi method was applied to achieve the consensus of the panel of experts. This agrees with the approach adopted by Holt and Hughes (2021), utilising semi-structured interviews and applying the Delphi method to achieve consensus.

Experts were contacted individually by using online platforms such as WhatsApp and Microsoft teams to conductct the interviews for each of the three Delphi technique iterations. This approach is in line with the recommendation made by (Toronto, 2017). Theparticipants did not know each other and their identities or participation was not divulged to anyone, including their fellow panellists. This was done to preserve confidentiality,as well as to avoid undue influence from fellow participants. The interviews were conducted at different times and dates for each iteration. In summary, the Delphi interviews followed a guideline developed by (Brown, 2018), which liststhe following four fundamentals for such interviews:

- participating experts are selected by a moderator (researcher), who remain anonymous to each other so that each may freely express their opinion;
- information is reviewed and refined over several "rounds" by the moderator;
- the moderator provides controlled feedback of the collective view;
- statistical collation of results.

4.4.5.9 Delphi Instrument

A Delphi research instrument is widely used to gather data on a poorly understood phenomenon and works well to improve understanding of problems, opportunities, solutions and developing forecasts (Skulmoski et al., 2007). Delphi surveys do not prescribe a required number of rounds, and some use iteration until consensus is achieved, while most adopt between 2 and 9 rounds of iteration, with the most common number being three rounds (Masud et al., 2014, Sitlington and Coetzer, 2015, Sakhnini and Blonder, 2015, Chang Rundgren and Rundgren, 2017). This study employed the three-stage approach (Figure 4-1) in line with the proposal advanced by Hasson et al.

(2000a), and these stages are 1) interviews proposing relevant lean constructs, 2) determining the most important constructs of the lean framework, and 3) reach consensus on the developed framework.

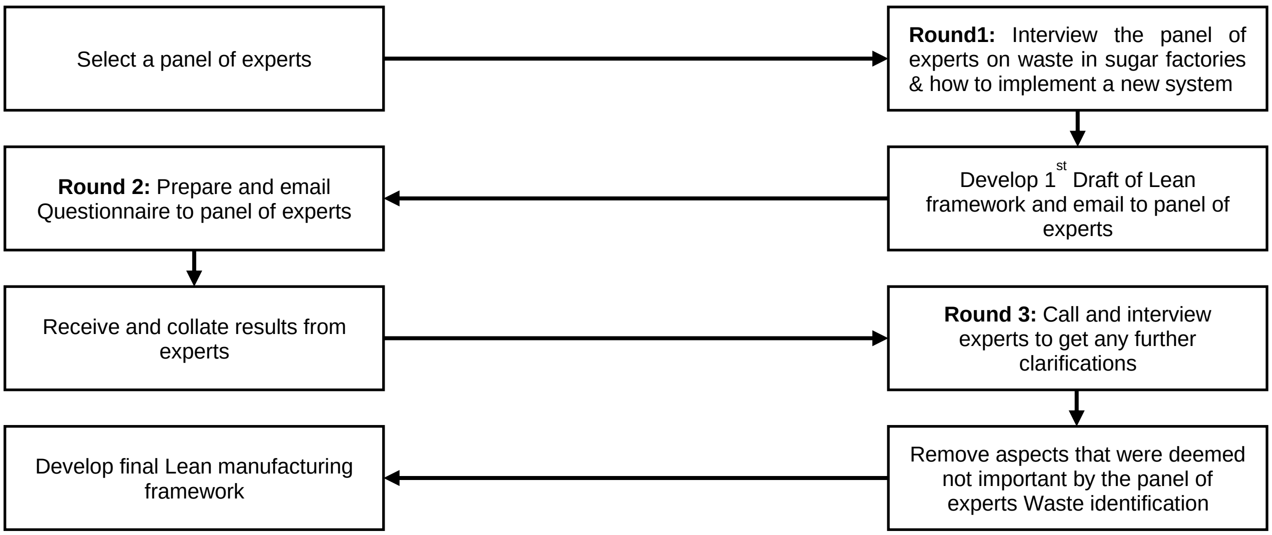

Figure 4-1: Delphi Technique Framework

Round 1: A Delphi questionnaire generated mainly from an extensive literature review on lean manufacturing was sent to the panel of experts during the first round of the Delphi process. Following recommendations made by Polit and Beck (2008), the interview questions and questionnaires were developed mainly from published literature. The study gathered several opinions and expert views on lean implementation in the sugar industry. Custer et al. (1999) opine that the open-ended questionnaire serves as an essential cornerstone for asking them specific information about a content area, which supports the use of the semi-structured interview type.

The responses from the participants were used to develop a well-structured questionnaire instrument that was used for round two. This procedure satisfies the iteration procedures requirement of the Delphi development process suggested by (Hsu and Sandford, 2007).

Round 2: A second questionnaire is handed out to the experts in round 2, so each participant can review it based on the information they provided in the first round. Participants rate each item from 1 to 5 according to the extent to which they agreed with it. A five point Likert scale was used to measure the level of agreement or consensus, ranging from strongly disagree, disagree, undecided, agree and strongly agree. Shariff (2015) submits that using this Likert scale enables the study to measure the degree of convergence of opinions from panel participants on the subject under investigation. In this round of the Delphi process, consensus-building started, and outcomes were shared with participants as recommended by (Jacobs, 1996).

Round 3: A Delphi panellist's third and final round involved reviewing the items and ratings summed up in the previous round and specifying any differences or disagreements. Participants were again asked to review their position and rate the extent to which they agreed with the item rankings. This procedure is also supported as necessary in achieving further consensus and may result in some increase in the level of agreement (Pfeiffer, 1968, Weaver, 1971, Jacobs, 1996)

4.4.5.10 Data Analysis

The study must predetermine the criteria and definition for consensus that will be used Miller (2006), an opinion or expert viewpoint on a topic is considered consensus when a certain percentage of the approval votes falls within a designated range. Academics and researchers define consensus differently, and one has to choose the definition most suitable for their study's context (Hsu and Sandford, 2007). Eighty per cent of votes on a seven-point scale must fall within two categories to achieve consensus ((Ulschak, 1983). On the contrary, Green (1982) suggests that consensus is reached when seventy per cent of the experts on the panel require a four-point Likert rating, with a median item score of 3.25 or high. Different views are held by Scheibe et al. (1975), arguing that percentage measures are insufficient for determining the consensus, and the consensus is better determined by taking into account the stability of expert responses in successive iterations.

The Delphi process incorporates qualitative and quantitative data ((Hsu and Sandford, 2007). In agreement, Hasson et al. (2000a) emphasise that careful attention must be given to managing qualitative and quantitative data for data analysis of the Delphi process. In the first round of the Delphi process, qualitative data is typically generated, while quantitative data tends to be generated from the second round onwards as researchers start to seek consensus among the experts on a subject matter (Hasson et al., 2000a, Hsu and Sandford, 2007). Qualitative data was generated and collected from the first round and analysed through content analysis techniques for this study. The data collected were grouped into relevant themes: critical success factors, challenges, and manufacturing waste, in line with the step-by-step guide given by Braun and Clarke (2006). This procedure followed the recommendation of Hasson et al. (2000a) on how to treat and analyse first-round qualitative data from a Delphi process.

Descriptive statistics such as mean and mode were employed to determine consensus for quantitative analysis of the data generated from round 1 of the Delphi process. Literature does not provide a standard to measure consensus in the Delphi study, regardless of the type of data employed (Boote et al., 2006). However, McDonald (2009) recognises that arithmetic mean, a measure of central tendency, is widely used and accepted as a measure of consensus among the experts' opinions. In their study, Njuangang et al. (2017) recommended that a factor understudy that scores group arithmetic mean of 3.28 will be accepted, while those with mean scores of less than 3.28 were resubmitted panel of experts for re-rating. The same consensus measuring method was adopted for this study's second, and third rounds of the Delphi technique. Experts were asked to rate how they agreed with sugar manufacturing waste, success factors and challenges, as consolidated from the five participants. Each rating was based on a five-point Linkert scale which ranged from 'strongly disagree' to 'strongly agree'.

4.4.5.11 Validity

Validity refers to the extent to which a research instrument measures what it is intended to measure, and there are two types of validity: face and content validity (Miller, 1993, Mitchell, 1991).

4.4.5.12 Face Validity

According to Hatzichristos and Giaoutzi (2006), face validity refers to how clearly an instrument can be seen to measure the appropriate concepts. For Secolsky (1987), face validity is defined as the suitability of the content of a test or item (s) for a particular purpose, as perceived by test takers and users. Mullen (2003) describes face validity as a subjective assessment of whether or not the instrument measures what it must measure. An instrument with high face validity is clear, understandable, readable and unambiguous (Parenté et al., 2005). Experts identified the constructs of the developed framework and confirmed the unambiguous nature of the instrument used to collect expert opinions, which means that the Delphi method used for this study has high face validity. Also, the consensus of experts participating anonymously enhances face validity, as Winzenried (1997) opined that the consensus formed in the final round ensures the instrument's validity. Shelton (2010) observes that the stronger the consensus, the stronger the face validity of the results. For this study, a panel of experts of five experts was constituted, and a consensus was formed in the third and final round of the iterations—this guaranteed stronger face validity of the instrument.

4.4.5.13 Content Validity

Hasson et al. (2000a) define content validity as involving the judgments of an expert panel about a questionnaire's content regarding how objectively and comprehensively it examines and includes the characteristics of a particular domain. By incorporating literature into the data collection instrument, pretesting the instruments, thoroughly analysing the data from the first questionnaire, and including expert panellists who are knowledgeable about the topic, content validity can be improved (Hasson et al., 2000a). Through rounds 2 and 3, experts were granted an opportunity to review their opinion submissions. Grisham and Walker (2008) confirm that this strengthens the Delphi approach in achieving high content validity. Islam (2021) agrees that content validity is assured and made stronger by using a panel of experts and consensus-building through iterations with the Delphi technique.

For this study, content validity was achieved by 1) developing questions based on an extensive literature review, 2) adopting a three-round Delphi approach to ensure iterations and consensus development processes enhance content validity, and 3) adhering to a strict expert qualification and experience procedure to ensure experts are knowledgeable.

4.4.5.14 Reliability

In research, a study's reliability is equally important as it must be ensured to give a study true meaning and reliable outcomes or findings. Hasson et al. (2000a) define reliability in the Delphi technique as the extent to which two different panels of experts can replicate results. Due to the open-ended nature of the instrument in the first round and the heterogeneity of the participants, Lincoln and Guba (2013) recognise that it is difficult for two or more panels to achieve similar outcomes on the same topic. Lincoln and Guba (2013) further suggest an alternative criterion of the four criteria procedure that guarantees reliability and must be encouraged throughout the iterations, is made up of the following pillars 1) credibility (truthfulness), 2) fittingness (applicability), 3) auditability (consistency) and conformability. The suggested alternative of the four-pillar criterion was employed at every round of the Delphi technique undertaken,to guarantee a more robust instrument and ultimately, the study's reliability.

4.4.6 Phase 2 - Quantitative Phase

Lean implementation framework validation work was done on one of the Mozambican sugar factories. This section lays out how the framework evaluation was conducted. In line with phase 2 of the exploratory sequential mixed method design, it is at this stage that a quantitative design was employed to confirm the robustness and validity of the lean implementation framework developed in phase 1 of the chosen study design.

4.4.6.1 Framework Evaluation

This research evaluated the impact on efficiency and productivity, of the developed lean implementation framework on Mozambique's largest sugar manufacturing and processing company. According to Nyamuzihwa (2017), the company contributes about 60% of the total sugar produced in Mozambique. Tripp (1985) argued that it is acceptable to generalise results from case research strategies, whether in a quantitative or qualitative method, and it is a way to accumulate and leverage wisdom from various cases.

4.4.6.2 Target Population

For Taherdoost (2016), the target population is the total number of cases or individuals from which the study has drawn a sample. According to Saruchera (2014), a population represents the whole mix of elements from which conclusions can be derived. Furthermore, Saruchera states that a target population is a group of individuals or research groups with certain characteristics in common, making them a valuable group for researchers. The second segment of this research is the quantitative method and aims to evaluate the framework developed through the Delphi method. There are four leading sugar factories in Mozambique. Therefore, the target population was all four. Secondly, the outcomes of this study would be generalised to all the sugar factories in Mozambique. The target population at the factory where the framework was deployed was the total number of permanent employees (200) at that chosen Mozambique sugar factory.

4.4.6.3 Selection of factory to deploy the Lean Implementation Framework

Choosing cases is a researcher's most important task, since this also sets out the direction for the research agenda (Seawright and Gerring, 2008). Case selection is an important component in qualitative or mixed-method research designs, and there are many recommendations on case selection techniques (Koivu and Hinze, 2017). Further supporting the argument that case selection is crucial, Goertz (2017) claims that in mixed methods, case selection is the critical link between methodological approaches and it has the potential to reduce many problematic methodological issues associated with confounders and generalisation.

Mozambique's sugar industry has four sugar mills, making the population small (N=4). A single case study with a purposive sampling method was adopted for this study, in line with the guidance given by (Yin, 1994). In numerous studies, researchers acknowledge the power of a single case study to meet the needs of an in-depth analysis of a unique phenomenon or to gain more understanding of a research problem (Yin, 2000, Stake, 2005, Merriam and Kee, 2014). In addition, Koivu and Hinze (2017) report that the case study is a commonly used research strategy for proving causal relationships, identifying causal mechanisms and discovering new causal conditions.

However, according to Gerring (2007), choosing a good case from a small population is a daunting task for many researchers, given that the outcomes will need to be generalised to the population. For a multi-case study, Gerring (2008) reviewed case selection procedures and reported nine purposive case selection procedures for the nine case types: typical, diverse, extreme, deviant, influential, crucial, pathway, most-similar, and most-different cases. Again for a multi-case study design, a seven-step procedure was proposed by Seawright and Gerring (2008), which includes the following case type basis, typical, diverse, extreme, deviant, influential, most similar and most different cases. Statistical tests such as hat analysis and Cook's distance statistics are useful among researchers in choosing between the nine or seven case selection procedures. Similarly, cross-tabulations may also be helpful in the case of a diverse-case analysis (Seawright and Gerring, 2008).

Yin (1994) submits that the case selection procedures for a single case differ significantly from those used for multi-case study designs. It is also plausible for academics and researchers to employ predetermined case selection criteria without the need to achieve the selection through statistical justification (Babaheidari et al., 2013). For single case selection, Yin (1994) proposed four strategies and matched these strategies to the purpose of the case inquiry from which a researcher can choose the most suitable case selection strategy. Among these strategies are the critical case, which is ideal for testing a new theory or framework; the extreme case method, which studies events and phenomena that are inaccessible to scientific investigations; and the prelude case, which is appropriate for examining questions to be investigated under multiple case designs (Yin, 1994).

Phase 2 of this exploratory sequential mixed methods design sought to test a conceptual framework on a single case basis. Therefore, by matching a purpose to a predetermined case type or the corresponding suitable case type for the application, (Yin (1994), the critical case type was selected and used to choose one case out of four. Rolland and Herstad (2000) explain that a critical case is often recognised as one with specific interest and strategic implications in the research problem investigated. For this study, the sugar processing business was the criteria for the specific interest, while production installed capacities shall be used to define the strategic content. Therefore, the AD sugar factory was selected in line with the criteria laid out above as a case to evaluate the impact of the developed lean implementation framework.

4.4.6.4 Sampling Technique

Sampling is the process of getting a subset of participants from a sampling frame or the entire population (Taherdoost, 2016). According to Etikan and Bala (2017), this sampling process can be achieved through two main methods, namely 1) probability or 2) non-probability sampling. There are random, stratified, systematic, cluster, and multistage sampling techniques within the probability sampling frame, while the bucket of strategies for the non-probability sampling method includes convenience, purposive, snowball and quota sampling (Boora, 2021).

Phase 2 of the exploratory design sought to get insight and measure perceptions about the impact of the implemented multi-stage framework and then generalise findings for the entire population. Different Sampling strategies were employed for the various framework stages: 1) the selection of the steering committee members, 2) measure of awareness across the population to determine alignment, and 3) measuring the overall framework effectiveness at the AD factory.

Purposive sampling was used to select the lean implementation steering committee members at the AD Factory. Etikan et al. (2016) postulate that convenience and purposive sampling techniques are cheaper and adequate where inferences to the whole population need not be made. Again, Suen et al. (2014) infer that purposive sampling also called judgmental sampling, is mainly applied when conscious decisions on a sample need to be made based on the qualities or qualifications of participants.

Several researchers recommend a simple random sampling technique as a probability sampling method of choice for studies that seek to generalise their conclusions (Boora, 2021, Acharya et al., 2013, Taherdoost, 2016). So, to measure the effect of training and awareness, a simple random sampling was conducted to draw a sample.

Lastly, stratified random sampling was employed to draw a sample from permanent staff to measure the framework's effectiveness at AD Factory by surveying employee perceptions of the developed lean implementation framework on factory performance. Generally, stratified sampling is applied when the population from which samples are being taken is not homogeneous and is used to obtain a representative sample (Etikan and Bala, 2017). Similarly, Barreiro and Albandoz (2001) submit that for a stratum more homogeneous within the strata, but still different across the entire population, the stratified technique is more appropriate than random sampling. The population was divided into three strata: Senior management, Middle Management and employees. Senior management level was defined as starting from the engineer level upwards, while Middle management was the Supervisor/foreman level, then employees referred to as operators, artisans and helpers.

4.4.6.5 Sample Size

Sample size refers to the percentage of the population representative of the whole target population (Sekaran and Bougie, 2010). According to Desu (2012), sample size determination remains one of the biggest challenges among researchers using experiment or survey strategies. Govender et al. (2014) define sampling as a technique of choosing a portion of a sufficiently representative population of generalizing the population characteristics. Sample sizing should ensure that sufficient samples are selected to meet statistical requirements, large samples waste resources, while undersized samples can render the study findings irrelevant. (Lenth, 2001). Generally, Rutterford et al. (2015) view that sample size requirements mainly depend on the study's analysis method. Taherdoost (2016) offers the sample size determination formula N=P(100-P)Z^2/E^2, where N is the sample size, E is the per cent maximum error allowable, and P is the percentage occurrence of a condition, and Z is the value corresponding to the required confidence level. Typical values of these variables in social science research are, P=+/-50%, E = +/-5% and Z=1.96 (95%confidence) (Taherdoost, 2016, Kotrlik and Higgins, 2001).

Leedy and Ormrod (2015) note that the appropriate sample size depends on two main factors: the level of precision required by the study and the characteristics of the population - a heterogeneous population requires smaller sample sizes than a homogeneous one. Typically, a population size of lessthan 100 cases requires 100%

sampling, a population of around 500 cases requires a 50% sample size, a population of around 1500 requires 20% sample size, and for a population of over 5000 cases, a case sample size of 400 is acceptable(Leedy and Ormrod, 2015).

Neuman and Kreuger (2003) suggested that for a population under 1000, a suitable sample size would be 30% of the population. At the same time, Omair (2014) asserts that sufficiently representative sample size is one where 50% of the population is used as the sample size. Sekaran (1983) and Stoker (1985) provide a guideline (Table 4-3) to calculate the suitable sample size as a percentage of the total pupation.

Table 4-4: Guideline for Sampling

Population	Percentage Suggested	Number of Respondents
20	100%	20
30	80%	24
50	64%	32
100	45%	45
200	32%	64
500	20%	100
1,000	14%	140
10,000	4.5%	450
100,000	2%	2000
200,000	1%	2000

Source: (Sekaran, 1983, Stoker, 1985)

Firstly, purposive sampling was employed to choose the steering committee, a heterogeneous group of 12 members. The lean steering team (Lean team) comprises twelve members: six operation supervisors, two process engineers, two maintenance engineers, and two senior managers. The constituents of the lean team covered the factory's departmental spectrum, and selected members were at the appropriate level of authority,with a minimum of 10 years of experience in operation, which is in line with the steering team selection recommendations guided by Chakravorty (2010).

For alignment measurement (Training and Awareness) and framework effectiveness stages, the study employed a 100% sample size on the secondary data available and a 50% (100 participants) sample size for the survey questionnaire to gather primary data needed from a population target of 200 full-time workers. Adopting these sample size measures ensures that it is done in line and fits into several researchers' submissions (Desu, 2012, Acharya et al., 2013, Leedy and Ormrod, 2015)

4.4.6.6 Data Collection

A variety of data collection methods are available, namely interviews, questionnaire surveys, historic archives analysis, participant observation, and outside observations, and these can be used in combination where appropriate (Jasti and Kodali, 2014). For the framework validation by a case, the researcher used carefully constructed questionnaires to gather required primary data in line with the constructs given in the new proposed framework. The questionnaires were developed and customised for each stage of the conceptual lean implementation framework designed to measure different aspects. Various researchers submit that a survey of this nature is self-reported, meaning that the individual responding to it represents their knowledge, perception, or experience (Bowling, 2005, Shariff, 2015). The questionnaire is self-administered: the person answering it completes it on their own.

A suitable questionnaire instrument was designed to collect quantitative data from the operations of the chosen case study, then the framework's effectiveness was quantitatively analysed. According to Hofstee (2006), a questionnaire is a structured interview in which respondents are asked the same questions and can usually choose only one option to answer the questions (yes/no, on a 5 point Linkert scale). According to Govender et al. (2014), questionnaires are an easy and reliable instrument for collecting data from a large sample. Govender et al. further note that questionnaires can easily be standardised and distributed through various means such as telephone, email, social media, or by post, making it a cost-effective method. Leedy and Ormrod (2015) acknowledge that questionnaires usually lead to participants being more truthful when answering questions due to the distance between the researcher and the participant.

It was noted that while the disadvantage of a limited in-depth gathering of data, the questionnaire has many advantages, such as high participant confidentiality, ease of analysis and comparison of data and a high response rate of between 50 to 70 % (Hofstee, 2006, Makanyeza, 2014). For many researchers, the credibility of research is acceptable when a minimal questionnaire return rate of 50% is required (Roth and BeVier, 1998, Babbie, 1990, Dillman, 2000, Rea and Parker, 1992). Also, Lewin (2005) notes that a 40% response rate is acceptable in quantitative studies employing questionnaires, while three reminders sent to participants have generally increased the response rate by up to 30%.

Due to the overwhelming advantages and appropriateness of quantitative study data collection, questionnaires were employed for the framework evaluation in this study. The researcher adopted the strategy recommended by Lewin (2005) and reminded participants regularly, with some being reminded up to four times to increase the response rate. Regular reminders via telephone and email follow-ups were strategies to improve the survey return rate, with a target minimum response rate of 40 % adopted for this study.

The lean team underwent thorough training on lean principles, tools, the proposed lean framework, and the lean policy formulated by the AD sugar factory. The training was in the form of a train-the-trainer format, which enabled the team members to grasp the fundamentals and the proposed framework, while also allowing them to teach other employees. A questionnaire instrument was developed to measure the level of alignment before and after training and awareness interventions of the lean implementation framework. The questionnaire had eight multiple-choice questions on a 4 Linkert scale, namely, 1- Strongly Disagree, 2 – Disagree, 3- Agree, and 4 -Strongly Agree. A score of four (4) shows the highest level of alignment, while a score of one (1) shows the lowest level of Alignment (see Appendix II). This measure was done to establish the importance and impact of the training on the lean implementation framework at AD Sugar Factory. Following the criteria in the sample size selection section, one hundred (100) participants were randomly selected at the AD sugar factory and were given the questionnaire before and after training for their response.

The Gemba methodology was adopted and deemed suitable for data collection for the framework's value stream mapping. The approach was in line with recommendations by Rahani and Al-Ashraf (2012) on data collection for a VSM process. With this method, the steering team walked through the production lines observing activities and timing for each activity. The steering team did a Gemba walk following the whole product processing line, and observations were made. Notes were taken, while questions clarifying or verifying statements were discussed with the section process and maintenance managers. Again, statements were verified through in-depth discussions with senior operating staff for a particular area. This ensured that observations and findings were not because of a once-off non-recurring process deviation. The team conducted three Gemba walks per month for the whole of 2019’s thirty-two-week cane crushing season.

The effect of lean implementation was measured by using an employee perception questionnaire survey. The objective of this questionnaire was to establish if the implemented constructs of the developed lean implementation framework directly impact AD Factory's performances and efficiencies. The stratified random selection of participants was carried out to draw a sample from the total population. This method helped to improve the representation of all different categories of employees and reduced variability (Acharya et al., 2013). AD Factory employees were grouped to form five stratas, according to their job grades (A-E), and random sampling from each stratum was employed to select the sample. Participants were asked to fill in 13 questions by rating their level of agreement on a 5-Lindert scale (Agree, Strongly Agree, Don't Know, Disagree, and Strongly Disagree).

Lastly, a comparison of AD factory performances was carried out employing secondary data from the case factory. Production performance data reports from 2017 up to 2020 were used to assess performance, or the impact of the framework on the efficiency and productivity performance parameters.

4.4.6.7 Data Analysis

Analysing quantitative data involves collecting measurable data, evaluating their significance, as well as determining causal relationships, and this method can be used both descriptively and inferentially (Ali, 2021b, Kaffemaniene and Kulese, 2021). Creswell (2014b) defines quantitative research as a type of research that explains phenomena by collecting and analysing numerical data using mathematically based methods (in particular, statistics). This study employed four levels of quantitative analysis: inferential statistics, waste-time analysis, quantitative performance gap analysis, and descriptive statistical analysis on employee perception of the implemented framework. The software IBM SPSS statistics 27 and MS excel 365 statistic package were used for descriptive and inferential statistics quantitative data analysis. While quantitative performance gap analysis was done through benchmarking of secondary performance data over two periods (before and after implementation), and the waste-time analysis was done using the Value Streaming Mapping (VSM).

It was deemed appropriate and essential to set the mark of departure on this lean journey through communication and training. Various authors argue that lean program training and awareness is a solid foundation on which the framework implementation can leverage (Shafiq, 2014). Awareness and alignment survey responses were noted and input into the IBM SPSS statistic 27 package. A comparison of the alignment levels before and after training and awareness was made, and an inferential t-test to determine whether the alignment levels changed significantly between the two periods.

Inferential statistics allow researchers to extrapolate conclusions from a sample to a broader population, and it is helpful for several applications such as investigations and experiments (Marshall and Jonker, 2011). Ali (2021b) concluded that researchers could generalis e the findings from inferential statistics to the whole population because of their inductive methodology. Marshall and Jonker (2011) provide guidelines in Table 4-4, which will help determine the appropriate inferential statistical test suitable for this study.

Table 4-5: Types of Statistical Tests		
Type of Data	Number of Samples	Statistical Test
Binary	One or paired	McNemar's test
	Two independent samples	Chi-squared test or Odds ratio
Nominal	One or paired	Stuart test
	Two independent samples	Chi-squared test
Ordinal	One or paired	Wilcoxon test
	Two independent samples	Mann-Whitney U-test
Interval/ratio	One or paired	Wilcoxon test (non-nominal)
		A paired t-test (Nominal)
	Two independent samples	Mann-Whitney U-test (non-normal)
		Unpaired t-test (normal)

Source: (Marshall and Jonker, 2011)

Inferential statistics is primarily concerned with estimation, which remains central to studying statistics, and approximate measurements are called acceptance procedures. According to Marshall and Jonker (2011), inferential statistics measure the significance of the difference between two samples to establish whether this difference is statistically significant or simply by chance.

Through visualisation and quantification, Value Stream Mapping (VSM) can improve complex workflows of manufacturing or processing business entities (Nowak et al., 2017). The second set of data analysis was the quantifying of waste-time along the process line using the quantitative aspects of the value stream mapping tool. According to Shafiq (2014), researchers must use their clocks to time processes during Gemba walks to provide the quantitative data as waste-time numeric input to the VSM tool. Total waste time is calculated using the following quantitative input data: 1) Cycle time – the time it takes a part to be processed until the next part is removed in seconds, 2) Changeover time – the time it takes to change products, 3) Uptime – the number of operators, the number of product types, the number of pack sizes, the available working time per shift (excluding breaks), the scrap rate and the inventory (Shafiq, 2014, Sullivan et al., 2022, Kumar and Shinde, 2019, Ebba and Mathilda, 2021). All processes on the value chain were grouped as value-adding (VA), necessary but non-value-adding activities (NNVA), or non-value-adding activities (NVA) categories. The observations and findings were discussed with the section managers to validate them and ensure that the occurrences observed were not because of a once-off non-recurring process deviation.

The third level of quantitative data analysis was the first step in confirming the impact of the implemented framework on the performance measures at AD Factory. Performance data based on the efficiency measures proposed in the new lean implementation framework was obtained from secondary data sources, AD Factory daily reports and published mill performance data on the SASTA website. This approach is supported by Ebba and Mathilda (2021), who opine that secondary data from ethically obtained company reports are a rich source of data, especially when evaluating the effect of implemented performance improvement measures. The performance data made accessible by the AD Factory management was sorted and tabulated to check performance changes before and after the lean implementation framework. Gap analysis through efficiency measures benchmarking was performed before and after the framework implementation. The difference in the outcome of the gap analysis formed the basis of the conclusion on the impact of the developed lean implementation framework on the AD Factory performance

The last level of quantitative data analysis for this study was to answer the research question of whether the newly developed framework would improve the productivity and efficiency of the Mozambican sugar factories. The framework's impact on the sugar sector in Mozambique was established by measuring employees' perceptions of the overall effect of the framework on the AD Factory. The Ms Excel 365 statistical package was sufficient to run the chosen descriptive statistical data analysis to perform descriptive statistics regarding variables in a study, group opinion, or a characteristic of a group (Hasson et al., 2000b, Marshall and Jonker, 2011, Kaushik and Mathur, 2014, George and Mallery, 2016). The descriptive statistical analysis in the study followed the recommendations by Trabelsi et al. (2021), to utilise measures of central tendency (median 'x' and mean 'x'), dispersion (standard deviation 'SD') and interquartile range with the analysis done through the Excel 365 statistical data analysis tool. Kaushik and Mathur (2014) note that using descriptive statistics is one way of explaining data by summarising observations and samples; either these summaries form the basis for a comprehensive statistical analysis or are sufficient for a particular investigation on their own. Ali (2021b) emphasises that statistical data is presented in an easily digestible, quantitative format to be understandable and useful in descriptive statistics.

Quantitative data were analysed using descriptive statistics to check the significance of variations before and after awareness measurement data. This was to establish that changes in awareness measures are not due to chance. The changes in AD factory efficiency measures were measured through employee perceptions of the causal factors for the difference in factory performances.

4.4.6.8 Data Validity and Reliability

Punch (2003) argues that validity deals with how a respondent can candidly and meticulously respond to questions, which he believes partly depends on the respondents' attitude and mind condition. Furthermore, Mouton (1996) asserts that reliability refers to the notion that different research participants being tested by the same instrument at different times should respond identically to the instrument. Overall reliability constitutes a fundamental aspect of quantitative research, as Lankshear and Knobel (2004) suggested that researchers in quantitative studies should endeavour to use valid and reliable instruments.

Both validity and reliability help a researcher to understand whether the research outcomes will reflect the phenomenon under study (Leedy and Ormrod, 2015). The validity of a measure is the extent to which a measurement measures what it is intended to measure (Leedy and Ormrod, 2015). The validity can be viewed on two fronts: internal and external validity (Drost et al., 2012). On the other hand, Diamantopoulos and Schlegelmilch (2000) define validity as the extent to which the measurement is free of random and systematic errors. For perfect validity, Diamantopoulos and Schlegelmilch (2000) assert that the measurement outcome truly reflects the measured trait of a variable, while for a perfectly reliable measure, the random error is equal to zero. The study attempted to ensure that the overall research process is valid by providing the validity of different stages in the validity framework where applicable, using a guideline proffered by Mouton (1996), as shown in Table 4-5.

Table 4-6: Validity Framework

Stage in the research process	sources of error	Methodological strategy	Outcome	Epistemic (Validity-related) quality or criterion
Conceptualisation (Concept analysis)	Complex notions	Literature review	Concepts/definitions	Theoretical validity (clarity/scope)
	Vagueness	Clear and logical definitions		
	Ambiguity			
	Abstract concept			
Operationalisation	poor sampling of items	Scale validation	Measuring Instruments	Measurement Validity (Construct Validity)
	Leading questions	Face Validity		
	Scaling errors	Pilot test		
Sampling	Bias	Probability	Sample	Representativeness
	Heterogeneous populations	Sampling		
	Incomplete sampling frame	Stratification		
		Optimal sample size		
Data collection	Observation effects	Multi -method	Data sets	Reliability
	Interviewer bias	Proper training of fieldworkers		
	Respondent bias			
	Context effects			
Analysis/Interpretation	Competing/rival conclusions or explanations	Appropriate techniques of analysis	Conclusions/results/findings	Inferential validity
		Detailed understanding		

Source: Research Validity framework by Mouton (1996)

Validity requires the absence of both systematic and random errors, while reliability only considers the absence of random errors. There are different validity assessment approaches, namely content validity, empirical validity and construct validity. To enhance external validity, this study undertook the following strategies: 1) a real-life setting instead of a laboratory-controlled environment, 2) The sample size and method of choosing participants were representative of the population.

4.4.6.9 Reliability

According to Bryman and Bell (2007), the commonly used measure for internal consistency is Cronbach's Alpha, which refers to the degree to which the same dimension is measured consistently by the instrument. A zero value indicates no internal reliability, meaning the instrument cannot be relied on to measure the dimension or construct it is developed to measure. While a Cronbach's Alpha of 1 represents perfect internal reliability, it may also reflect the duplication of items or questions. Therefore Cronbach's Alpha gives researchers the confidence that the instrument measures the dimensions or constructs that the instrument has been developed to measure. Angelica and Napitupulu (2020) argue that a Cronbach's Alpha value greater than 0.6 (>0.6) is acceptable. In the study by Shen et al. (2020), a reliability measurement above 0.6 Cronbach Alpha was deemed acceptable . The formula adopted to calculate the Cronbach Alpha is given as

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\Sigma\sigma_i^2}{\sigma_x^2}\right)$$

For instance, Hair et al. (2011) note that Cronbach alpha values of between 0.6 and 0.9 as acceptable, while the average variance extracted greater than 0.5 is acceptable as a measure of convergent validity. Various authors contend that Cronbach alpha of 0.5 to 0.7 is moderate and acceptable, also values of between 0.7 to 0.9 are acceptable and considered excellent, while anything under 0.5 is deemed unacceptable (Koo and Li, 2016, Oveisgharan et al., 2006, Agbasiere, 2021, Ong et al., 2021). For this study, reliability is treated following the reliability guide shown in Table 4-6.

Table 4-7: Reliability Guide

1	**Perfect consistency**
$0.7 \leq \alpha < 0.9$	Excellent
$0.5 \leq \alpha < 0.7$	Acceptable
$\alpha < 0.5$	Unacceptable

Source: (Koo and Li, 2016, Oveisgharan et al., 2006, Agbasiere, 2021, Ong et al., 2021)

In this study, the research instruments' reliability was ensured by testing for composite reliability of the designed instrument, and acceptance is based on prescribed existing literature on empirical evidence on the topic under study.

Secondly, reliability analysis was run and confirmed using an appropriate and robust statistical package widely used in similar research worldwide. Mouton (1996) indicates that validity can also be perceived as a synonym for ‘best approximation to the truth.’

4.5 Ethical Considerations

Sikes (2004) asserts that research is an activity that affects people’s lives and should be ethical. Sikes further states that ethics are perceived as applying moral principles while interacting with others to be respectful and fair and promote healthy relationships. Ethical considerations should be considered when a study or research involves human beings or creatures with the ability to think, feel and can experience distress, be it physical or psychological. Broadly, ethical issues are mainly involve informed consent, protection from harm, right to privacy, and honesty with colleagues (Leedy and Ormrod, 2015). Concurring, both De Vos et al. (2011) and Herbst and Coldwell (2004) prescribed ethical research issues like the study and participant's rights, confidentiality, plagiarism and harm avoidance.

Accordingly, Leary (2001) maintains that every researcher must protect participants’ rights and welfare, and one other way to achieve this is to obtain informed consent. Leary (2001) insists that obtaining informed consent indicates that the researcher respects participants’ privacy and provides them with the required information, which could help them to decide whether to agree or decline to participate in the study. Therefore, the researcher obtained informed consent from the participants on privacy and rights issues. Again, it was made clear that participants were welcome to terminate and withdraw without feeling obliged to continue if they felt physically and emotionally uncomfortable at any point in the research process.

Regarding confidentiality issues, the identities of all the participants and their responses were kept confidential. Participants took numerical code identities such as Participant 1, 2, etc. To ensure the high integrity of the research outcomes, the researcher always made sure that straight and honest communication with colleagues and respondents, as well as data collection and capturing, were done without any attempt to temper with the outcomes. A turn-it-in software was used to ensure that the research study plagiarism was within the university acceptance level of +/-10%, thereby ensuring the integrity of the study. Lastly, the ethical clearance certificate for this study was obtained from the University of KwaZulu Natal Research Ethics Committee.

4.6 Chapter Conclusion

This chapter outlined the research design used inthe study. It depicted how the exploratory sequential design was organised to ensure that the methodological approaches chosen would be able to answer the research questions. Phase 1 and 2 of the design clearly laid out how qualitative and quantitative data were collected and analysed. Furthermore, the study's validity, reliability and generalisability were also discussed to ensure that the credibility of the study outcomes. The following chapters present the findings of the study, as well as therespective discussions.

CHAPTER 5:

QUALITATIVE STUDY RESULTS (PHASE 1 - FRAMEWORK DEVELOPMENT)

5.1 Overview

This study used different approaches to accomplish the two main objectives: developing a suitable lean implementation framework and evaluating it. This chapter presents the results and findings from the Delphi study design to build the framework. Again, the Delphi process defined specific objectives such as determining waste, critical success factors and efficiency measures. The results are therefore based on the iterations conducted; in this case, three-round criteria results are presented. Findings are only noted, while a detailed discussion of these findings is covered in the following chapters.

5.2 The Results of Panel of Experts Selection

Powell (2003) posited that a Delphi technique's success rests on the combined experience and the quality of the panel of experts. In this research, five experts were selected for the panel. Thus, the study focused on having a panel with the appropriate diversity of opinions and quality suggestions for solving the research problem. This selection criterion ensured that the panel had vast up-to-date experience, was diverse, and was very knowledgeable about the subject.

Hsu and Sandford (2007) described the Delphi technique to gather expert opinions from experienced practitioners in the Mozambique sugar factories. The study selected the experts in line with Skulmoski et al. (2007) description of a quality panel of experts. Firstly, the study sought practitioners who had expansive knowledge about the processes in the sugar industry. Secondly, the experts had tremendous experience in the sugar industry, and the experience was obtained from more than two of the four plants in Mozambique. Thirdly, the experts had the capacity and willingness to participate in the research. Fourthly, the experts had time to participate in the Delphi technique. Lastly, the experts were conversant with both the English and Portuguese languages and able to communicate by email effectively. Table 5-1 below summarises the selected panel of experts and their background information.

Table 5-1: General Background of the Panel of Experts

Expert	Job title/Position	Experience in Sugar Industry	Plants Knowledgeable
1	Production Manager	31 years (15 in Mozambique)	• Xinavane • Mafambisse • Maragra • Marromeu
2	Factory Manager	30 years in Mozambique	• Xinavane • Mafambisse
3	Electric & Instrumentation Manager	10 years in Mozambique	• Xinavane • Mafambisse • Maragra
4	Planning Manager	11 years in Mozambique	• Xinavane • Mafambisse
5	General Manager	35 years (20 in Mozambique)	• Xinavane • Mafambisse • Maragra • Marromeu

Source: Primary Data – Selected Panel of Experts

The panel of experts had amassed 117 years of experience in the sugar industry, with 86 years being experience obtained explicitly from the four major Mozambican sugar factories. The average experience of an expert was 23 years. The job titles cut across the critical aspects of sugar factories, i.e., production, electrical, instrumentation and mechanical sections. Expert five is a general manager who provided perspectives from an overall and overarching position. It is imperative to note that experts comprised managers who execute technical and human resources roles in their day-to-day duties. Thus, there was no need to look for a standalone human resources expert. The experts' names were withheld and presented as Expert A to E for ethical reasons.

The Delphi technique was done by engaging the panel of experts in three rounds. Firstly, the study conducted telephone interviews asking experts unstructured and open-ended questions. The study compiled the first-round results by content analysis and then designed and emailed experts more specific questions that required quantification through a questionnaire. In this second round, the study developed the first draft of the framework and sought experts' views on the same. The final draft was crafted and circulated upon getting the responses to check if the experts had further additions and/or subtractions.

5.3 Delphi Technique Round One Results

The main areas of focus in this round were efficient measures, waste and critical success factors for the Mozambican sugar industry. Participants were asked to remarkwhich efficiency measures were critical in sugar factories. Theywere also asked to identify the process or product inefficiencies that affect the main efficiency measures and what could be done to improve. Lastly, the experts were asked to provide opinions on the critical success factors for a wholesome initiative suggested to remedy the identified inefficiencies or waste.

A 100 % response rate was achieved when participants gave their opinions regarding the efficiency, waste and critical success factors. Table 5-2 details the summary results of the experts' responses, a collation of measures and their respective ranking regarding the sugar industry in Mozambique.

Table 5-2: Efficiency Measures, Lean Wastes, and Critical Success Factors

Aspect	Expert opinion or remark	Expert*					Ranked Score**
		A	B	C	D	E	
A. Important Factory Efficiency Measures in the Mozambican sugar factories							
Important efficiency measures in the Mozambican sugar industry	Overall Time Efficiency (OTE)	1	1	1	1	1	5
	Cane to Sugar Ratio (CTS)	1	1	1	1	1	5
	Cane quality	1	1	1	0	0	3
	Loss Time Available (LTA)	1	0	0	1	1	3
	Steam percentage in cane	0	0	1	0	0	1
	Boiling House Recovery (BHR)	0	0	0	1	0	1
	Cost per unit (CPU)	0	1	0	0	0	1
B. Remarks on inefficiencies in the Mozambican sugar factories							
Human resources	Shortage of technical skills	1	1	0	1	1	4
	No multiskilling & skills transfer	1	1	1	0	0	3
	Poor quality leadership	0	1	0	1	1	3
	No cross functional skills & organisation learning	1	1	0	0	0	2
	Challenging to train people	1	1	0	0	0	2
	Overstaffed at lower levels	1	0	1	0	0	2
	Locals are willing to learn	0	0	0	0	1	1
	Dependent on ex-pat labour	0	1	0	0	0	1
Transportation	Multiple trips in repackaging	1	0	0	1	0	2
	Poor initial footprint against	0	1	0	0	1	2
	Multiple trips in reprocessing	1	0	0	0	0	1
Defects	Out-of-spec of product are reprocessed	1	0	0	1	1	3
	No strict cane requirements	0	1	0	1	1	3
	Out-of-spec within process salvageable	1	0	1	0	0	2
	Out-of-spec of product sold at a discount	1	0	0	0	0	1
Motion	Inefficiency from old plant designs	1	0	0	1	1	3
	Layouts with no scope for expansion	1	0	0	0	0	1
Inventory	Endemic over stocking of critical parts	1	1	1	0	1	4
	Challenging to implement JIT due to location	1	0	1	1	0	3
	Wastage of packaging material	0	1	0	0	1	2
	Pilferage of sugar stocks	0	0	0	0	1	1
Overprocessing	Not a big challenge	1	0	1	0	0	2
	Underutilization of by-products	0	0	0	1	1	2
Overproduction	Common to cater for off-season	0	0	0	0	1	1
Waiting time	Mechanical & electrical breakdowns	1	0	0	1	1	3
	External conditions impacting supplies	1	0	0	0	0	1
	Quality reworks	0	0	0	0	1	1
C. Implement a new system in Mozambican sugar processing companies							
Critical success factors to implementing a new system in Mozambican sugar processing companies	Train & retrain the tactical team as trainers	1	1	1	1	1	5
	Brief everyone & do repeat briefs	1	0	1	0	1	3
	Ensure adherence to legislative requirements	0	1	0	1	1	3
	Audit & publish results	1	0	1	0	1	3
	Recognize & reward employees	1	1	0	0	1	3
	Culture change	0	1	0	0	1	2
	Select a tactical team	1	0	1	0	0	2
	Provide necessary support & systems	1	0	0	0	1	2
	Continuous feedback & adjustments	1	0	0	1	0	2
	Align your metrics with business strategy	0	0	0	1	0	1
	Remove roadblocks	0	0	0	1	0	1

**1 indicates that the expert raised the matter and 0 means the expert did not raise the matter. ** is the total number of experts who raised the matter. Source: Primary data*

5.4 Discussion of Round One Results

5.4.1 Mozambican Sugar Factory Efficiency Measures

The experts provided a total of seven measures on factory efficiency measures. The overall time efficiency and cane to sugar ratio were popular, having been raised by all five experts as key factory efficiency measures. This view from the panel of experts is supported by Gunawan et al. (2018), who emphasise that cane to sugar ratio, or the overall recovery measure of a sugar factory, is a true reflection of factory efficiency- the higher, the better the efficiency. Similarly, in their study, Wamalwa et al. (2014) concluded that lower factory time efficiency positively correlates to factory efficiency and can be used to measure sugar factory efficiency. Three out of five experts raised the cane quality and loss time available. Some experts opined that loss of time efficiency feeds into overall time efficiency; thus, they could not say it is a significant measure of efficiency as a stand-alone outside the OTE (overall time efficiency). Steam percentage in cane, boiler house recovery and cost per unit, were less popular. Upon probing for further explanations, experts agreed that the cane-to-sugar ratio and overall time efficiency are the main efficiency measures in the Mozambican sugar factories. The other measures invariably feed into these two.

5.4.2 Wastes In the Mozambican Sugar Industry

The panel of experts expressed varied sentiments on the sources of inefficiencies in the Mozambican sugar factories. As depicted in Table 5-2, the most popular sources of inefficiencies included the following,

1) *Shortage of technical skills*

The point that came out strong from all the panellists was that there is an inherent shortage of local (Mozambican) skilled labour, which affects the smooth operations of the mills in the country. Most rural and urban households receive their income from low-skilled jobs which account for 70% of employment in Mozambique (Hartley et al., 2019). Anjo et al. (2017) note that local skilled labour is scarce across all Mozambican industries, leaving companies to hire more foreign labour. The very high low skill contribution compared to the skilled labour contribution is a result of poor schooling (Esposito et al., 2011), the lower percentage of educated population (Mario and Nandja, 2006), and lack of training and education facilities and infrastructure (Anjo et al., 2017). The result therefore, is consistent with available empirical evidence. Hired foreign labour would increase costs on the country's production and manufacturing entities, including the Mozambican sugar industry, making the sector less competitive on the global market front. Again, a lack of competence in technical skills leads to long equipment breakdowns and frequent process shutdowns, which adversely affect the swift and even flow of product through a production line required for improved performance and effectiveness of Lean.

2) Lack of multiskilling among staff

Multiskilling as waste for the sugar industry resonates with various empirical findings on the multi-skilled workers improving productivity and efficiency of organisations. The lack of these multiskilled teams will result in lost opportunity for efficiency improvement, regardless of the manufacturing systems employed. Multiskilling is synonymous with cross-training, training the workforce to do more than one task (Nasirian et al., 2019). Singapore's government implemented the multiskilling of workers scheme to mitigate a significant drop in productivity in the construction sector (Shang et al., 2020). In support, Alony and Jones (2008) assert that employees' ability and capability to perform multiple tasks form the core of lean on the performance and efficiency improvement front. Again Shang et al. (2020) noted that due to the heavy incentives from the governments in the developed world to encourage worker multi-skilling, barriers were significantly rendered ineffective. A multi-skilled workforce is deemed a critical resource in manufacturing setups that reduce production costs and enhance employees' performance, ultimately positively impacting overall organisational productivity, flexibility, and efficiency (Ying and Tsai, 2017).

Therefore, it is reasonable that the panel of experts identified multi-skilling as a waste in the sugar industry since this competence fall right at the heart of any successful lean implementation. The outcomes from the experts as to the possible reason for the lack of multiskilling were inadequate extra compensation, lack of ability due to lower literacy levels, and the cost of training was prohibitive. These are supported by Nasirian et al. (2019), who add to the above list, diminishing returns that come with more scope, licencing requirements and management perceptions of greater benefit in the specialisation. The unique outcome from the experts was that one of the reasons is the desire of the local workforce to do the barest minimum. Any extra scope will be viewed as unfair work practices which often leads to violent illegal strikes that might cause prolonged shutdowns.

3) Poor quality leadership

Quality leadership begets quality operational performance and, subsequently, quality products. The characterisation of quality leadership is giving extra attention to and managing costs with caution, allocating adequate and appropriate resources for quality enhancement,management and monitoring, or assessing the quality leadership of the employees (Sorooshian and Ali, 2017). The lack of quality leadership in the sugar industry in Mozambique can be attributed to the weak training institutions and lower literacy levels across the country. Leadership is vital in managing costs, motivating employees and ensuring an effective lean manufacturing system for organisations. Without quality leadership, employee buy-in will be difficult to achieve, while general acceptance of the system might fail since, for practical implementation, top to bottom approach is required for efficient and supporting policy frameworks, incentives and fair, as well as effective resource allocation. Studies have shown that leadership quality is strongly positively correlated to a manufacturing firm's quality, efficiency and productivity (Dale and Duncalf, 1985, Garvin, 1986).

4) Repacking of sugar

The panel raised sugar repacking as a form of waste incurred by the Mozambicanindustry due to the inability of the sector to operate throughout the year, making sure sugar is available for customers when demanded. The participants noted that the setup of the mills and soil types make it impractical to keep delivering cane in wet seasons due to the inaccessibility of cane fields. Another common reason advanced was the hectarage under cane, for most sugar mills can only support a 32-week operating cycle before the raw material cane runs out.

5) Poor initial plant structures

The plant layout was also raised by participants as a significant source of waste. The long civil war in Mozambique virtually almost brought the sugar mills to a grinding halt due to infrastructural damages and disruption in operational and maintenance activities. The step-change from operating to just supplying a few domestic markets with a total capacity of about 20000 tons of sugar to an industry that is a major foreign currency earned after the service and mining sectors. This boom was achieved through the brownfield project to facilitate increased capacities to meet the local and export demands. The expected view was that the expansion projects on a small footprint resulted in plant design challenges and led to many movements of both product and workers. This is a waste that is costly to the sugar processing sector in Mozambique.

6) Reprocessing of out-of-specification products

Defects and out-of-spec product reprocessing were also highlighted as a significant waste in the sugar industry operating in Mozambique. Panwar et al. (2017) found that defects cause untold losses in the processing industry and noted that entities that have adopted lean had a significant reduction in defects and customer complaints. The results show again that with the Mozambican industry exposed directly to the international end-user markets, the number of product recalls and customer complaints rose sharply. According to the experts' opinions, the high defects rates could be explained by skill shortages and poor-quality leadership. Secondly, this waste has now been amplified due to the stringent world or global food safety standards adopted by the sugar sector in Mozambique to access the international market customers. They consider food safety and quality assurance certification as paramount to closing trade deals.

7) Poor supply chain due to location

Geographical locations of all the sugar industries are such that most of them are far from the essential transport network and in some instances, dilapidated road infrastructure and limited air transport infrastructure. Again, all three except for one, are located in the rural areas of Mozambique. Due to infrastructural challenges, the experts noted that it has resulted in waste of broken supply chain for critical spares and other consumables required for sugar production. The players in this sector resort to hoarding consumables and spares for ‘Just in Case’ purposes, thereby increasing the firm’s working capital. Also, the experts noted that the frequently broken supply chain leads to unplanned factory stoppages for very long periods while waiting for spares to be shipped from overseas or the regional neighbours. This too, is waste that must be reduced or eliminated.

8) Mechanical and electrical breakdowns

Another waste raised by the panel of experts is the frequent unplanned stoppages of manufacturing factories due to mechanical and electrical failures. These stoppages have cost the sugar industry millions of rands in production opportunity costs and fines for failure to deliver on sugar supply contracts. The participants who raised this waste pointed to skill shortages, lack of leadership and multiskilling within teams. This issue also finds its basis in empirical evidence suggesting that multi-skilling, leadership and upskilling are positively correlated to equipment availability (Chaudhuri and Jayaram, 2019, Kennedy, 2005). The participants also identified the lack of capital investment to replace ageing equipment as a major challenge. Another issue raised was the political or perceived political instability that has caused the slowing down of the needed capital investments in most ageing industry players. A negative correlation has been found between aggregate investment and political instability (Campos and Nugent, 2003).

Since the questions were open-ended, many inefficiencies or wastes emerged. Furthermore, at this round, no request was sought to provide thoughts on the degree of importance of impacting factory efficiency measures. The wide range of wastes provided by the panel of experts offered scope for implementing and using lean principles to remedy the same.

Table 5-2 classifies the waste raised by experts into the standard eight types of waste. The classification reveals that human resources waste had most of the issues. Defects and inventory had several wastes raised. Transportation and waiting time had minor issues raised. Motion, overprocessing and overproduction were not popular. Some experts noted that overprocessing is not a challenge in the Mozambican sugar factories since the clients do not have robust requirements. It was pointed out that even though it is a common practice for overproduction, such an initiative is not taken as a waste, since the cane supply is seasonal against an annual sugar demand. Thus, overproduction and stocking were perceived as necessary and important industry practices. Nonetheless, experts highlighted those inefficiencies within the stocking and packing processes would require some attention.

In light of the identified wastes in the Mozambican context, reference was also made to literature, and the identified wastes were mapped to their corresponding tools. The tools identified and mapped were suitable for the reduction or elimination of the identified wastes, in line with the submission by various authors that the most commonly employed tools for waste reduction in a continuous manufacturing environment are: TPM, JIT, Six Sigma, Kaizen, VSM, 5S, TQM and Kanban (Upadhye et al., 2010, Jiménez et al., 2012, Hodge et al., 2011, Natarajan and Venkatesan, 2018, Chahal and Narwal, 2017). These tools were considered for this study and deemed suitable for achieving waste reduction in Mozambique's sugar industry. There is no one size fits all approach when choosing these tools, different organisations pick and choose differing techniques in line with their organisational contexts. In agreement with this line of thought, Chahal and Narwal (2017) suggest that different tools can be used one after the other, simultaneously or merged as per the requirement.

5.4.3 Critical Success Factors for the Mozambican Sugar Industry

Experts suggested the critical success factors to implementing a new system in the Mozambique sugar factories. In this view, the need for continuous training was prevalent amongst the experts. They also highlighted the need for the process to be all-inclusive to achieve stakeholder buy-in, which is critical for the success of the proposed initiatives. The importance of keeping track of results, taking corrective actions continuously, as well as rewarding employees, were underscored. Few of the experts suggested that implementation teams be selected, while culture change initiatives are also required. Furthermore, some experts opined that a new system should be aligned with the overall business strategy, adequately resourced, and ensure that impediments are removed. Overall, the experts suggested that there is a wide array of critical success factors for implementing a new system in the Mozambican sugar factories.

5.5 Delphi Technique Round Two Results

The second round involved ranking the three themes established in round one of the Delphi process, namely, efficiency measures, wastes and critical success factors on a Likert scale of 1 to 5 (1- Strongly disagree, 2- Disagree, 3- Neutral, 4 – Agree and 5 – Strongly agree). Table 5-3 outlines the summary of the ranking as given by each expert.

A questionnaire was sent to the experts, requiring them to indicate their rankings on each efficient measure, factory waste and critical success factor that had been identified at round one. The response options were “Strongly disagree”, “Disagree”, “Neutral”, “Agree”, and “Strongly Agree”. The responses were then coded using a Likert Scale ranging from 1 being “Strongly disagree” to 5 being “Strongly agree”. Table 5-3 presents a summary of the coded responses. Furthermore, an arithmetic average of the scores was computed, then a decision was made to accept or remove that aspect. Aspects that scored 3.28 or more were “Upheld”, and those that scored less than 3.28 were “Removed”. Thus, those aspects that were upheld formed the consensus amongst the experts, whereas those removed implied that experts did not reach a consensus. Reference to 75% of the possible score as a consensus threshold agreed with the method used by various authors.

Table 5-3: Summary of the Rankings on the Themes from Round One

Aspect	Remark or Suggestion	Expert					Overall Score	Decision
		A	B	C	D	E		
Main efficiency measures in the sugar Factories	Overall Time Efficiency (OTE)	5	5	5	4	5	4.80	Accept
	Cane to Sugar Ratio (CTS)	5	3	5	5	5	4.60	Accept
	Cane Quality (Pol)	4	3	4	2	3	3.20	Remove
Human resources waste	Shortage of technical skills	3	3	4	4	5	3.80	Accept
	No multiskilling nor cross-functional skills	5	5	4	4	4	4.40	Accept
	Poor quality leadership	4	5	2	3	4	3.60	Remove
	No organisational learning	4	3	4	1	4	3.20	Remove
Transportation waste	Multiple trips in repackaging & reprocessing	5	3	4	5	4	4.20	Accept
	Poor initial footprint against	5	3	4	2	4	3.60	Remove
Defects waste	Out-of-spec of product reprocessing	5	4	4	5	4	4.40	Accept
	No strict cane requirements to farmers	2	4	4	4	5	3.80	Accept
	Out-of-spec within process	4	4	3	3	4	3.60	Remove
Motion waste	Inefficiency due to old plant designs	5	4	4	3	5	4.20	Accept
	Layouts with no scope for expansion	4	3	4	4	5	4.00	Accept
Inventory waste	Endemic overstocking of critical parts	5	3	3	3	5	3.80	Accept
	Challenging to implement JIT due to location	5	2	4	4	5	4.00	Accept
	Wastage of packaging material	5	5	4	4	3	4.20	Accept
	Pilferage of sugar stocks	4	3	4	3	5	3.80	Accept
Overprocessing waste	Underutilization of by-products	3	4	4	3	5	3.80	Accept
Overproduction waste	Common to cater for off-season	5	3	4	3	4	3.80	Accept
Waiting time waste	Mechanical & electrical breakdowns	2	5	4	3	4	3.60	Remove
	External conditions impacting supplies	4	4	4	3	4	3.80	Accept
	Offloading raw material Cane	3	3	3	1	3	2.60	Remove
	Loading of final products	5	3	2	1	4	3.00	Remove
	Quality reworks	4	4	4	5	4	4.20	Accept
Critical success factors to implementing a new system at Mozambique sugar processing companies	Select & Train the tactical Team as trainers	5	4	4	4	4	4.20	Accept
	Brief everyone & do repeat briefs	5	4	4	5	4	4.40	Accept
	Adherence to legislative requirements	4	4	4	5	4	4.20	Accept
	Audit & publish results	4	4	5	4	5	4.40	Accept
	Recognize & reward employees	4	4	5	4	5	4.40	Accept
	Culture change is required	5	4	5	5	4	4.60	Accept
	Provide necessary support & systems	5	5	4	4	4	4.40	Accept
	Continuous feedback & adjustments	5	4	4	5	4	4.40	Accept

Table 5-3 indicates which themes have been accepted and which ones have been removed or rejected.

5.5.1 Discussion of Round Two Results

The expert remarks upheld two measures on establishing the main efficiency measures: the overall time efficiency and the cane to sugar ratio, which scored 4.8 and 4.6 aggregated arithmetic means. Cane quality did not get a consensus as a primary efficiency measure, with an arithmetic mean of 3.20, falling short of the cut-off point of 3.28

As experts analysed wastes in the sugar factories, they found consensus on most aspects except leadership, organisational learning, a poor initial site footprint, challenges within the processes, breakdowns in the mechanical and electrical systems, and inefficiencies in the offloading and loading operations. Thus, the study remained with the primary wastes that required lean implementation solutions.

The study confirmed all the critical success factors identified in round 1 scored aggregate arithmetic mean above 3.75 as stipulated in the methodology section.

5.6 Delphi Technique Round Three Results

In the third round, the study developed a framework aimed at addressing performance improvement for the Mozambican Sugar industry. The efficiency measures, wastes and the critical success factors identified for the industry. A questionnaire was distributed with the draft framework to enable experts to share their opinions on each stage. In addition, the study validated the proposed framework using the validation methodology suggested by Nordin et al. (2012), who emphasised validation of the developed framework by using a panel of experts. The experts' response options described in round two were also used in this round. Table 5-4 provides the summary ranking results. The experts expressed affirmative responses to the suggested constructs for the framework. Through consensus among panellists, all the suggested aspects of the framework were upheld in round two.

Table 5-4: Summary Ranking Results for the Draft Framework Stages

Stage	Step	Expert					Overall Score	Decision
		A	B	C	D	E		
Preparation stage / Pre-implementation	Establish Lean policy & objectives	5	5	4	5	5	4.80	Accept
	Select & Train Lean Team	5	5	4	4	4	4.40	Accept
	Carry out a gap analysis for OTE & CTS	5	4	4	5	5	4.60	Accept
	Formation of a master plan of Lean deployment	5	5	4	4	5	4.60	Accept
	Simplify Lean system and procedures	5	5	4	4	5	4.60	Accept
	Brief all employees of Lean system & Gap	5	5	5	5	5	5.00	Accept
Implementation stage / Execution	Ensure proper housekeeping/5S	4	5	5	5	5	4.80	Accept
	Carry out Value Stream Mapping (VSM)	4	4	4	5	5	4.40	Accept
	Allocate time & resources	4	5	4	5	5	4.60	Accept
	Roll out Lean tools:							
	□ Total Productive Maintenance (TPM)	5	5	4	5	5	4.80	Accept
	□ JIT for non-critical parts	5	5	5	4	5	4.80	Accept
	□ Kanban	4	5	4	4	4	4.20	Accept
	□ Production smoothing (PS)	5	5	4	4	4	4.40	Accept
	□ Kaizen	4	5	4	5	4	4.40	Accept
	□ Total Quality Management (TQM)	4	5	4	5	5	4.60	Accept
	□ Six Sigma	4	5	4	5	5	4.60	Accept
	Facilitate the following commitments:							
	□ All employees' involvement	5	5	4	5	5	4.80	Accept
	□ Acquisition of appropriate technology	5	5	3	4	5	4.40	Accept
	□ Establish multifunctional teams	5	5	4	4	5	4.60	Accept
	□ Organisational & cultural change to Lean	5	5	4	5	5	4.80	Accept
	□ Active communication to all stakeholders	4	5	4	5	5	4.60	Accept
Post implementation stage / Generalization & Reward	Monitoring & evaluation							
	□ Continuously measure performance (Visual Display & Controls)	5	5	4	5	5	4.80	Accept
	□ Do audits & Gap analysis	5	5	4	4	5	4.60	Accept
	□ Continuous feedback & corrective actions	5	5	4	5	5	4.80	Accept
	Standardise Lean practices (Standardisation of Work)							
	□ Amend work standards	4	5	5	5	5	4.80	Accept
	□ Manage Lean practices	4	5	4	5	5	4.60	Accept
	Reward & recognize best performers							
	□ Award performance rewards	4	4	3	4	5	4.00	Accept
	□ Recognize best performers	4	4	3	4	5	4.00	Accept

The three framework stages were developed at this stage and the steps involved per stage were laid out. Also, a decision based on a consensus measure on whether to accept or not to accept was made.

5.7 Framework Validation by the Panel of Experts

The framework's three main aspects were also validated: its overall structure, abstractness, and allocation of roles and responsibilities. It is in line with the observation of various authors who posited that high abstractness structure and precise role allotment results in greater clarity and consistency of a framework (Agarwal et al., 2019, Manry, 2018).

Table 5-5: Framework Validation Summary Results

Stage	Question	Expert					Overall Score	Decision
		A	B	C	D	E		
A. Overall structure	Comprehensive approach and covers all the major waste in the sugar industry	4	4	4	5	5	4.40	Accept
	Provides a straight forward guide	5	4	5	5	5	4.80	Accept
	It is a simple process that can be easily understood	5	5	4	4	5	4.60	Accept
B. Abstractness	Whether the reader would understand the sequence of the implementation	4	5	3	4	5	4.20	Accept
	The stages are easy to understand and systematic guidance to successful Lean manufacturing implementation	4	5	4	5	5	4.60	Accept
	The suggested stages are logical and practical	4	5	4	5	5	4.60	Accept
C. Role and responsibility	Whether the framework provides information about the role of stakeholders in a Lean manufacturing environment	4	5	4	4	5	4.40	Accept

The experts ranked all the aspects that validate the overall framework structure, the framework's abstractness and clarity of roles and responsibilities of the stakeholders. It was established that the framework satisfied all conditions the panel of experts set for validation.

5.8 Chapter Conclusion

This chapter discussed the results from all the Delphi processes, leading to the successful development of the lean implementation framework. Lastly, the panel of experts was employed to validate the developed framework, thereby crediting the Delphi study results and processes.

CHAPTER 6

DISCUSSION OF PHASE 1 - QUALITATIVE STUDY FINDINGS

6.1 Overview

This chapter discusses the findings presented in the previous chapter. Again the findings chapter presents a newly developed Lean implementation framework was built from these constructs.

6.2 Efficiency Measures

Regarding the efficiency measures for sugar manufacturing, the study found that the main efficiency measures are Overall Time Efficiency (OTE) and Cane to Sugar ratio (CTS). These measures sought to define the basis on which the efficiency of the sugar industry can be measured. The measures will help guide the industry to the key indicators to monitor and control to ensure high factory performance.

The panel of experts brought up three main measures: Overall time efficiency measure, Cane to Sugar ratio, and Cane Quality as measured in Pol % from round 1 of the Delphi Technique.

Table 6-1: Efficiency Measures

Aspect	Remark or Suggestion	Expert					Overall Score	Decision
		A	B	C	D	E		
Main efficiency measures in the sugar Factories	Overall Time Efficiency (OTE)	5	5	5	4	5	4.80	Accept
	Cane to Sugar Ratio (CTS)	5	3	5	5	5	4.60	Accept
	Cane Quality (Pol)	4	3	4	2	3	3.20	Remove

After Round 2 of the Delphi technique, the panel of experts reached a predetermined agreement level of arithmetic mean above 3.28 score for the overall time efficiency and cane to sugar ratio. The cane quality was dropped as an efficiency measure for the sugar factories in Mozambique.

6.2.1 Cane to Sugar Ratio (CTS)

The study found that this ratio was considered one of the two most crucial indicators of a sugar factory efficiency measure that can be easily understood by operators and supervisors in factory operations in Mozambique. The panel of experts and the participants from the case study explained that Cane to sugar ratio denotes how many tons of raw material sugar cane is needed to produce one (1) ton of sugar (finished product). It therefore measures the efficiency of raw material conversion to the final product. The smaller the ratio means the factory requires less cane raw material to recover one ton of sugar. The better the sugar factory's efficiency, the less the product losses along the process value streamline. As seen from the study, operators and supervisors target a ratio of 8:1 to meet other downstream or dependent KPI measures for the whole operations. Various authors noted that benchmarking productivity and efficiency ratios such as CTS (Cane to Sugar) is highly recommended to improve sugar manufacturing business performance and profitability (Hanlon et al., 2002, Hanlon and McMahon, 2001).

It was also established that an easy-to-understand measure would be ideal due to the skills levels in the Mozambique industry, especially at the critical supervisor and operator levels. All employees could understand an indicator, especially those involved in the factory operations and controlling factory performances daily.

6.2.2 Overall Time Efficiency (OTE)

On KPIs, it was found that to measure time efficiencies, the OTE was the second measure of choice that could be well understood by the workers in the Mozambican sugar industry. This indicator covers a wide range of factory time efficiency measures for a sugar factory and condenses them into one easy-to-understand efficiency measure for OTE.

Overall time efficiency measures the total factory stops due to operational issues or equipment breakdowns. For an efficient factory, operational and equipment downtimes must be maintained at a minimum. This measure was deemed appropriate, especially for the Mozambican sugar industry, as it can easily be measured and controlled by the supervisory and operating staff. Several authors also note that OTE is one of the primary target KPIs for monitoring and addressing sugar mill inefficiencies and was used to manage efficiency improvements for the ailing Indonesian sugar industry (Sulaiman et al., 2019).

6.2.3 Summary Discussion of the Efficiency Measures

Therefore, for sugar factories in Mozambique, the main efficiency measures to monitor and control in order for the firms to compete in the global marketplace are OTE and CTS. The managers must establish their targets for the OTE and CTS to control the whole process and ensure a highly efficient sugar factory. The efficiency parameters identified by the experts agree with Gunawan et al. (2018), that the main sugar mill efficiency parameters are OTE and CST. The efficiency targets may be set based on set benchmarks. The benchmarking of efficiency measures in lean implementation leads to organisations' improved performance, quality and overall competitiveness (Comm Clare and Mathaisel Dennis, 2000). The authors concluded that benchmarking of efficiency measures in lean implementation will help identify performance gaps in productivity, speed and time, safety, customer satisfaction and quality, among other performance indicators. This will then lead to practical strategic goal setting and resource allocation to address specific gaps identified through benchmarking. The higher the OTE, the better, as it depicts low equipment breakdowns, leading to high and consistent factory production. The lower the CST, the better, as the factory uses fewer tons of cane (raw materials) for the same amount of sugar produced by a factory.

The identified measures were confirmed by expert consensus and supported by their effectiveness in the AD sugar factory case. The two measures are valid, reliable and easily understood by employees and management. Anagnoste (2018) states that KPIs should be relevant and easily understood by the staff that will use them, otherwise, they will not serve their intended purpose. Ibrahim (2020) adds that the team should easily understand these set KPIs that they will measure and manage. It is even more critical for the Mozambican sugar industry to make the measures easy to understand due to low literacy among the general populace constituting the labour force. Esposito et al. (2011) state that Mozambique is experiencing the adverse effects of low literacy and skills humper understanding of complex issues, especially at the operational and tactical levels.

6.3 Lean Waste Identification

The study identified a total of twenty-two waste synonymous with the sugar industry, which can be found in Table 6-2. Several unique wastes to the sugar industry were identified, waste such as 'burn to crush', cane quality and 'raw house' waste, which are unique to the sugar industry and were clustered into the eight lean wastes as given in the literature. The main cluster groups of waste into which these unique and specific waste were grouped are motion, inventory, talent, waiting, overproduction and overprocessing. The finding of eight waste in the Mozambican sugar industry conforms to the conclusion by various authors that most manufacturing and processing entities have waste which can be categorised into eight distinct lean waste namely: motion, inventory, talent, waiting, overproduction and overprocessing (Hines, 2009, Buonamico et al., 2017, Chahal et al., 2017, Alzahrani, 2021). It was evident within the waste identification process that some lean waste was much higher and more pronounced within the Mozambican sugar industry than others and adversely impacted business performance.

6.3.1 Discussion of Specific Wastes

In round 1 of the Delphi process, various types of wastes were identified and profiled in the results section in a tabular format. Consensus in round 2 resulted in removing only three out of twenty-two wastes identified by experts. The remaining nineteen wastes presented specific waste unique to the sugar industry.

Table 6-2: Wastes dominant in the Mozambique Sugar Industry

Aspect	Remark or Suggestion	Expert					Overall Score	Decision
		A	B	C	D	E		
Human resources waste	Shortage of technical skills	3	3	4	4	5	3.80	Accept
	No multiskilling nor cross-functional skills	5	5	4	4	4	4.40	Accept
	Poor quality leadership	4	5	2	3	4	3.60	Accept
Transportation waste	Multiple trips in repackaging & reprocessing	5	3	4	5	4	4.20	Accept
	Poor initial footprint	5	3	4	2	4	3.60	Accept
Defects waste	Out-of-spec of product reprocessing	5	4	4	5	4	4.40	Accept
	No strict cane requirements to farmers	2	4	4	4	5	3.80	Accept
	Out-of-spec within process	4	4	3	3	4	3.60	Accept
Motion waste	Inefficiency due to old plant designs	5	4	4	3	5	4.20	Accept
	Layouts with no scope for expansion	4	3	4	4	5	4.00	Accept
Inventory waste	Endemic overstocking of critical parts	5	3	3	3	5	3.80	Accept
	Challenging to implement JIT due to location	5	2	4	4	5	4.00	Accept
	Wastage of packaging material	5	5	4	4	3	4.20	Accept
	Pilferage of sugar stocks	4	3	4	3	5	3.80	Accept
Overprocessing waste	Underutilization of by-products	3	4	4	3	5	3.80	Accept
Overproduction waste	Common to cater for off-season	5	3	4	3	4	3.80	Accept
Waiting time waste	Mechanical & electrical breakdowns	2	5	4	3	4	3.60	Accept
	External conditions impacting supplies	4	4	4	3	4	3.80	Accept
	Quality reworks	4	4	4	5	4	4.20	Accept

Table 6-2 presents specific waste that the sugar industry in Mozambique needs to focus on, and eliminate or reduce for efficiency to improve. All these unique wastes scored an average score of not less than 3.60 out of a possible maximum score of 5 points.

Lack of multiskilled teams or cross-functional teams and out-of-specification products were identified as two top wastes in the Mozambican sugar industry. The industry has had tough times with customer product returns. Food safety standards compliance has been low due to the preferential agreement that ensured most of the sugar from the Mozambican factories goes to the European market for further processing, not to the final consumer. Therefore, the shift to supplying to final consumers requires strict food safety auditable practices; hence the waste of out-of-spec products is now coming to the fore. A culture shift regarding meeting product safety needs to be pursued. Multiskilling teams will take training and upskilling employees to function at more than one station, thereby reducing the number of employees required for the sugar mills in Mozambique.

The second group of waste scored the 4.20 average mark, multiple trip movement of product for repackaging and reprocessing. The severity of this waste is mainly because the sugar industry in Mozambique stocked up on sugar for decanting and repackaging during the annual shutdown maintenance. Quality reworks and waste packaging materials fall into this second group. These two are a direct result of out-of-spec product returns either for repackaging or reprocessing. Product reprocessing and repackaging cause considerable losses in labour hours, energy usage and opportunity costs.

Still, within this second group, employees are inefficient due to walking within their work areas. One primary reason for this type of waste to be topping was that the sugar mills in Mozambique started on a smaller scale and have since expanded, thusresulting in workstations for the employees being far apart, leading to employees spending much of their time moving between these stations. While it is a challenge to eliminate the source of this waste due to the capital investment required, this finding should inform any future design thinking or concepts for the sugar mills.

Other unique wastes in the sugar industry are rampant product pilferage, overstocking critical spares and skills shortages. The panel of experts noted that pilferage is a significant contributor to the basket of waste, mainly due to the poverty levels in the country. Secondly, the skill shortages directly result from the legacies of the civil war, where schools were closed, and a culture of not sending children to school developed. Again, poverty means the resources for paying for education become very scarce. Poverty and skill shortages, as identified in this study, will better inform the Mozambican government on policy formulation in line with poverty reduction and compulsory free education, as well as vocational training centres throughout the country. Once these have been addressed, the experts contend that the problem of pilferage and skills shortages will reduce in the workplaces, including sugar factories.

Poor leadership and equipment breakdowns were noted to be unique wastes affecting the sugar industry. Leadership is responsible for organisational culture and effectiveness; should they fail, it is costly to the sugar factories. Equipment breakdown was also noted, and the score was similar to the poor leadership waste. According to the panel of experts, equipment breakdowns and poor leadership directly result from the skill shortage waste. Upskilling will undoubtedly go a long way in addressing these two wastes, leading to improved performances of the Mozambican sugar factories.

It is pretty evident from the analysis that all these wastes are interconnected in many ways. Addressing one will likely have a positive impact on the other. Therefore, managers are encouraged to target those unique wastes that impact many others, such as upskilling, education and training of employees. According to the panel of experts, these will resolve much of the other wastes if they are done correctly and efficiently.

6.3.2 Discussion of Clusters of Waste

This sub-section outlines a discussion of findings on lean waste, with the main focus of condensing the identified individual waste.. The profiled lean wastes were weighed by the central tendency arithmetic mean approach and were ranked to identify the most common waste affecting the sugar industry. Table 6-3 shows the analysis and ranking for the eight types of lean wastes in order of severity. The finding of eight waste in the Mozambican sugar industry conforms to the conclusion by various authors that most manufacturing and processing entities have waste which can be categorised into eight distinct lean waste, namely: motion, inventory, talent, waiting, overproduction and overprocessing (Hines, 2009, Buonamico et al., 2017, Chahal et al., 2017, Alzahrani, 2021).

Table 6-3: Ranking of Lean Wastes in the Mozambican Sugar Industry

Ranking	Type of Waste	Arithmetic Mean Score	% Contribution
1	Motion	4.100	13.11 %
2	Inventory	3.950	12.63 %
3	Human resources	3.933	12.57 %
4	Defects	3.933	12.57 %
5	Transportation	3.900	12.47 %
6	Waiting time	3.867	12.36 %
7	Overproduction	3.800	12.15 %
8	Overprocessing	3.800	12.15 %

6.3.2.1 Motion Waste

The study established that the most dominant lean waste in the Mozambican sugar industry is motion waste. The average age of the sugar industries in Mozambique is about 100 years, built and owned by the government for the better part of these years (Lazzarini, 2017, Leite et al., 2016, Neil-Tomlinson, 1977). The study results revealed that there has been a horizontal and vertical expansion of these existing manufacturers over the years. In most cases, these resulted in workstations far spaced from each other, as the expansion sought not to disturb old structures in production at the time. Due to design issues, these brownfield expansion projects require operators and employees to move long distances within their work areas.

As a result of the stretches and the required movements of employees, the sugar manufacturers in Mozambique experience high waste due to the non-value adding but necessary movements of employees within their sections. The common historical factory design deficiencies meant that motion waste became the number one (1) significant waste with the highest percentage score of 13.11% for the sugar industry in Mozambique. Similarly, after conducting a value stream mapping for an Indonesian sugar manufacturer, Setiyawan et al. (2019) concluded that motion waste accounts for the top 5 lean waste in sugar mills.

6.3.2.2 Inventory

Geographical locations of all the sugar industries are such that most are far from the essential transport network and, in some instances, dilapidated road infrastructure and limited air transport infrastructure. Again, all three except for one, are located in the rural areas of Mozambique. Due to infrastructural challenges, the experts noted that it has resulted in waste of broken supply chain for critical spares and other consumables required for sugar production. The players in this sector resort to hoarding consumables and spares for 'Just in Case' purposes, thereby increasing the firm's working capital. Also, the experts noted that the frequently broken supply chain leads to unplanned factory stoppages for very long periods while waiting for spares to be shipped from overseas or the regional neighbours. This waste contributes an overall of 12.63%, making it the second largest contributor to total waste in the Mozambican sugar industry.

6.3.2.3 Human Resources/Talent Waste

It was revealed by the study that there is a vast shortage of skilled labour in Mozambique, due to low literacy levels and high school dropouts as a result of poverty. Anjo et al. (2017) concur by noting that the high skills shortages in Mozambique result from poverty and ill-prepared graduates coming out of tertiary and vocational institutions. The lack of skills challenge has increased human resources costs in several ways. Examples highlighted during the study include that it becomes difficult to form cross-functional teams, high dependency on the costly expatriate labour for skill and low-performing work teams, which results in poor process controls and subsequently, increased reprocessing and equipment breakdowns.

Also, the skills and literacy issues have forced the sugar industry to employ more people on tasks that would ordinarily be done by fewer, to try and cover the competence gaps. This over-employment has led to avoidable higher employment and payroll costs. So, it was observed that talent waste ranks among the top five wastes in Mozambique's sugar industry, contributing a significant 12.57%.

6.3.2.4 Defects Waste

Like human resources waste, defects waste equally contributes 12.57% of the total waste in the Mozambican sugar industry. What was evident from both the Delphi panel of experts was the very high rate of reprocessing of the sugar for two main reasons, out of specification on colour, moisture and poor packaging customer returns. According to results from the case study, most defects are directly related to sugar export to consumers. Mozambique's sugar industry did not adhere to international food safety, defence and quality standards pre-2017 EU sugar trade reforms. This was mainly so since Mozambique exported raw sugar to refineries for further processing and final packaging. With the expiry of the EU preferential trade agreements, the sugar industry in Mozambique was now exposed to the high demanding and quality-sensitive consumers in the export markets, thus leading to many product returns and customer complaints. Among the four sugar manufacturers, the rate of reprocessing out-of-specification sugar and customer returns significantly rose. With these returns, the costs of reprocessing started to be felt by the industry.

Again, the waste of defects in Mozambique's sugar industry resulted in increased equipment breakdowns and unplanned factory stoppages. The study's observations based on the interactions with the experts reveal that the leading cause of these interruptions and stoppages is a lack of skills and capabilities on the part of the technical and operations employees.The skill shortages in the Mozambique sugar industry emanate from low literacy rates and not fully equipped graduates being churned out of the country's institutions (Anjo et al., 2017). As a result of all of the above, defect wastes contributes significantly to the overall waste of Mozambique's sugar industry and needs closer attention if the sugar mills are to improve their operating efficiencies noticeably.

6.3.2.5 Transportation Waste

The operating nurture of the Mozambican sugar industry is such that it is a seasonal 32-week batch operating cycle. Although the sugar manufacturing processes are in seasonal batches, the market demands continuous product supply, and the sector must meet this demand throughout the year. The restriction of sugar imports into the country due to industry protectionist government policies compounds the demand-side market pressures. Therefore, the universal strategy co-opted by the sugar manufacturers in Mozambique is to manufacture the product in large quantities to adequately meet customer demands during the 20 weeks of factory off-crop maintenance. Suhardini et al. (2021) reckon that transportation within sugar factories is a significant contributor to reduced factory performances, and unnecessary transportation should be eliminated to improve the efficiencies of the sugar sector.

Moving products to the on-site storage warehouses results in huge transportation and storage costs. While these costs cannot be avoided, they lead to handling waste of product transportation using mobile equipment and storage space associated costs. The transportation waste in the Mozambican sugar industry is the fifth predominant significant waste in the sector, with a percentage score of 12.47%.

6.3.2.6 Waiting Time

It was clear from the study that it is common among the sugar manufacturers in Mozambique to use road transport to move the raw material from the fields or plantations to the factory for processing. Any slight rain showers would hamper the transportation of the raw material cane due to road slippery and haulage vehicles getting stuck in the fields. The consistent wet weather in the coastal areas where these companies are located means frequent operation factory stops while waiting for roads to dry up to start receiving raw materials. Also evident from the results was the high turnaround time for the haulage vehicles, either at loading or offloading points, as they must queue to be loaded or offloaded one at a given time. Lastly, the work-in-progress storage vessel levels tend to slow manufacturing processes as frequent high vessel levels slow down processing flows, leading to stations waiting for extended periods to lower levels or receiving station raw materials.

Several studies have also indicated that waiting time, if unchecked, could be a massive contributor to sugar mill inefficiencies, with the Australian industry paying particular focus and efforts to reduce this type of waste (Higgins, 2006), same with the sugar industry in Cuba (Milan et al., 2006), as well as the sugar industry in Brazil (Lamsal et al., 2017).

Again, the Indonesian sugar manufacturers' overall waiting time waste was ranked as the number one lean waste that needs to be reduced to improve mill efficiencies and productivity (Setiyawan et al., 2019). Waiting time waste manifested as the sixth-ranked waste in the Mozambican sugar industry, scoring 12.36 per cent.

6.3.2.7 Overprocessing Waste

This waste emanates mainly from two primary sources in the Mozambican sugar industry and contributes about 12.15 % to the total waste basket. Firstly, low raw sugar colours than what is required by the export and domestic markets. Secondly, customers for the molasses by-product need a certain Brix and purity. Higher than targetted Brix and purity results in missed opportunities due to overprocessing. According to the panel of experts, the lack of required skills and understanding of customer demands and the negative effect of overprocessing on the overall business objectives, is the major contributor to this waste.

6.3.2.8 Overproduction

Due to the seasonal nature of the Mozambican sugar industry, the mills over produce in 32 weeks to cover for the 20 weeks of market demands when they are stopped for annual maintenance. The product stocking ensures that the domestic markets do not suffer from product shortages at any time throughout each year. However, the overproduction causes cost overheads due to storage spaces and rehandling when decanting bulk-packed sugar into smaller packages to supply consumers during the 20 weeks of shutdown maintenance. In this case, the 20-week shutdown period also coincides with the time needed for sugar cane to mature for harvest, so very little can be done to reduce this waste.

6.4 Critical Success Factors for the Sugar Industry in Mozambique

The study finding on critical success factors for the sugar industry shows that eight main factors would guarantee the success of this vital industry. Most of the participants agreed with the highest recorded Delphi consensus level on the factors listed in Table 6-4.

Table 6-4: Critical Success Factors for The Sugar Industry in Mozambique

Aspect	Remark or Suggestion	Expert					Overall Score	Decision
		A	B	C	D	E		
Critical success factors to implementing a new system at Mozambique sugar processing companies	Select & train the tactical Team as trainers	5	4	4	4	4	4.20	Accept
	Brief everyone & do repeat briefs	5	4	4	5	4	4.40	Accept
	Adherence to legislative requirements	4	4	4	5	4	4.20	Accept
	Audit & publish results	4	4	5	4	5	4.40	Accept
	Recognize & reward employees	4	4	5	4	5	4.40	Accept
	Culture change is required	5	4	5	5	4	4.60	Accept
	Provide necessary support & systems	5	5	4	4	4	4.40	Accept
	Continuous feedback & adjustments	5	4	4	5	4	4.40	Accept

As seen from the table above, a total of eight critical success factors and all the factors were accepted**.**

6.4.1 Train the Tactical Team as Trainers

Training is a critical success factor forlLean implementation in the sugar industry. The panel of experts agreed with a 4.20 mean score consensus level. Literature supports this finding with Ahmed et al. (2020), noting that in most lean implementation failures, the lack of training and awareness has been identified as the primary root cause. In their study, Yahya et al. (2019) also concluded that training and awareness result in better productivity, efficiency and quality, if done before lean implementation.

Throughout the study, it came out clear that low literacy levels affect the implementation of lean systems in the Mozambican sugar industry. The gap and education interruptions experienced by Mozambique due to colonial and civil war legacies have negatively impacted how employees, especially the lower levels, perceive and understand performance improvement initiatives such as the lean manufacturing system.

A weak education and training system, as well aslimited business sophistication, are the primary reasons for Mozambique's low ranking of 137 out of 138 on the World Economic Forum's Global Competitiveness Index (GCI) (Aga et al., 2021). Aga et al. further state that Mozambique also ranks low 148 out of 157 on the World Bank's Human Capital

Index, which measures productivity based on health and education performance.The experts who participated in the Delphi showed difficulties in getting most factory and operations employees to read and write, which are the critical pillars of lean implementation. Therefore, low literacy levels are a key impediment to applying lean in Mozambique.

The lack or shortage of technical and management skills is another dimension of the finding under the training critical success factor of the Mozambican labour force. The reason put forward would be summarised two-fold: the low literacy rates, as has been discussed already and the poor quality of the university and vocational graduates. A finding supported by Aga et al. (2021) concluded that there is an urgent need to improve the quality of education systems in Mozambique to close the skills gap caused by years of civil war. The participants noted that of the few graduates coming out of the tertiary and vocational institutions, there is a general lack of competencies. Hasan et al. (2018) found that one of the main impediments to productivity in developing countries is a lack and shortage of skills.

The skill shortage has forced the sugar industry to hire foreign labour drawn mainly from regional countries and worldwide. These are commonly referred to as expatriate labour. Expatriates bring in a wealth of experience in technical and managerial competencies to implement manufacturing systems such as the lean manufacturing system. However, hiring foreign labour gives rise to remuneration disparities,as companies try to attract the right skills to remain competitive. This gap has led to disharmony among the workforce accepting performance systems such as the lean system.

Unfortunately, unlike many other manufacturing or service industries, the sugar industry is limited to employing sugar industry-trained professionals because of the complexities associated with the processing line activities. This adds another dimension to hiring expensive foreign labour, which is a considerable cost to the company. The scenario again conflicts with the objective of lean- of lowering production costs in the industry to better compete with the global competitors. Therefore, training various teams at various levels will go a long way in alleviating many challenges arising from low literacy and the subsequent shortage of skills.

6.4.2 Brief Everyone and Do Repeat Briefs

Critical to successful lean implementation is effective organisation-wide communication through a briefing system was another finding regarding the critical success factors for lean implementation in Mozambican sugar factories. The media briefs can take various forms, with Shirode (2020) accentuating that effective communication can be via traditional media platforms such as noticeboards newsletters, or it can be achieved through the use of social media. Nordin and Deros (2017) acknowledge that there is a greater need for open and effective communication for a smooth lean implementation, which facilitates knowledge sharing, continuous improvements and continual evaluation.The same authors note that ineffective communication inlean implementation brings about confusion misapplication of lean principles and tools in an organisation, leading to failure of the manufacturing strategy.

6.4.3 Adherence to Legislative Requirements

One of the Lean system premises is right-sizing, which reduces the waste of human resources. The study established that the applicable laws of the host country must be adhered to at all times to attain a successful lean strategy execution. The finding is well supported by Hussein and Palaneeswaran (2018), who concluded that legislation is one of the main barriers to lean implementation in manufacturing organisations. Similarly, Helmold (2020) emphasises that lean management and manufacturing should start by building a solid foundation of legislative compliance for the implementation to succeed

In a country such as Mozambique, where there is less development and high unemployment rates, corporates are mandated to employ as many Mozambican citizens, as it contribute to the country's socio-economic well-being. So, in this context, the need for lean and those for the political environment are in conflict. Therefore, managers are expected to redesign the lean system and adapt it to meet the local needs and company objectives. Probable areas of conflict would be the area of rightsizing, automation and mechanisation. As mentioned in the background section, the sugar industry is the second largest employer in Mozambique, putting the sector on the political radar. Organisations need to navigate wisely to implement the lean system and achieve their objectives.

6.4.4 Audit and Publish Results

The study established that transparency through audits of lean implementation initiative results is crucial for successful lean implementation. Audits help anchor and sustain gains of lean implementation and enforce systems to prevent progress setbacks (Henrique et al., 2021, Sisson and Elshennawy, 2015, Araújo and Rentes, 2006, Murphree et al., 2011, Upton, 1996). The finding from the study is that auditing and publishing results are critical success factors for effective lean implementation in the Mozambican sugar industry. As a result of performance audits, findings and highlighted areas of improvement can assist sectors in public and private entities to increase the efficiency and effectiveness of organisations (Torres et al., 2019). According to Helmold (2020), audits refer to an organised and structured evaluation of the performance of a system, process, product, or any other area by internal or external auditors. As part of an audit, standardised criteria and questions are used to rate and approve or disapprove the assessed area, define areas for improvement and ensure effective implementation of improvements (Helmold, 2020).

6.4.5 Culture Change is required

Another finding from the study was that culture change is a vital pillar to successfully implement the lean system. According to Bhasin (2012a), culture change is a must-have critical success factor, should a lean implementation initiative achieve its intended objectives. This finding finds its basis in literature, with Cohen (2018) asserting that a lot of effort should be directed to institutional and cultural change for the successful implementation of lean. According to the outcome from the Delphi processes, experts confirmed that culture change from top to bottom is required for the Lean system to be successfully implemented. The culture change programme is tailored to conscientise stakeholders on lean manufacturing systems, their principles and tools. According to data from the study, such programmes can take many forms, including daily morning toolbox talk, awareness campaigns, engagement of consultant experts, and running lean competitions among departments. To support this finding, Schraeder et al. (2005) submit that tailored programmes effectively affect organisational culture change. For the sugar manufacturers, the training should be focused on the critical pillars of the lean manufacturing philosophy. It should be customised to suit and should be understandable by all employees, from senior management to the workshop level employees.

6.4.6 Recognize and Reward Employees

The study also gathered that success, no matter how big or small, must be celebrated to keep the much-needed morale and motivation for achieving even more. This finding focuses on the criticality of acknowledging, recognising and rewarding individuals and teams for targets or goals achieved or exceeded. Hines et al. (2020) confirm that implementing any operational strategy needs to recognise employee efforts to sustain a change management strategy. Recognition takes many forms, including monetary incentives, the team of the week visual notice board, lean champion of the week, and many other acknowledgements that may be non-financial. According to Hines et al. (2020), these create the energy and intrinsic commitment within and among employees to implement the actionable tasks to achieve objectives. Maintaining interest and generating trust among employees by recognising their efforts and accomplishments was deemed critical. As a result, recognition was classified as a critical success factor to lean system implementation in the sugar industry in Mozambique.

6.4.7 Continuous Feedback and Adjustments

Another finding agreed upon by the experts was that continuous feedback and adjustments to lean implementation methodology are critical success factors for Mozambique's sugar industry. The premise for this finding is the need to check the progress of action items implemented and measure their effects against the plan or desired outcome. In an organisation, feedback is the interaction among processes, inputs and outputs (Goetz (2011), and it occurs when there is a linkage between individual outputs and inputs within organisational processes (Ford, 2020). Corrective control measures are instituted at this stage, and continuous improvement initiatives are formulated and applied. To deploy a lean system successfully and effectively, work processes and initiatives must be monitored and controlled to get the desired outcome. It was considered that this stage is critical to the lean system implementation. The feedback information is essential in a firm, as it enhances process efficiencies and productivity

(Stansfield and Longenecker, 2006). It is also the view and submission by Sarkis and Talluri (2002) that managers use feedback to deploy a given organisational strategy effectively; hence its incorporation into the framework is necessary and critical.

6.4.8 Provide Necessary Support Systems

Support systems establishment was another critical success finding from the Delphi processes. Support comes in many forms, such as management, financial and other resource support systems are needed and fundamental to an effective lean implementation initiative in organisations (Van Landeghem, 2014, Trakulsunti and Trakoonsanti, 2021).

6.5 Framework for Lean Implementation in Mozambique Sugar Factories

After establishing the dominant waste and critical success factors for lean implementation, this section focuses on developing a lean implementation model incorporating the efficiency measures, lean waste and critical success factors. The suitable lean implementation framework for the sugar factories is a three-stage framework and context-specific. According to Sarkis and Talluri (2002), a framework must include an organisational strategic plan, current state, future state analysis, selection of alternatives, action plan, evaluation and feedback. Sarkis et alfurther noted that a framework should be able to evaluate essential factors quantitatively and qualitatively, both tangible and intangible.

Figure 6-1 presents the pictorial presentation of the proposed Lean implementation framework that was developed for the Mozambican sugar factories from the Delphi technique.

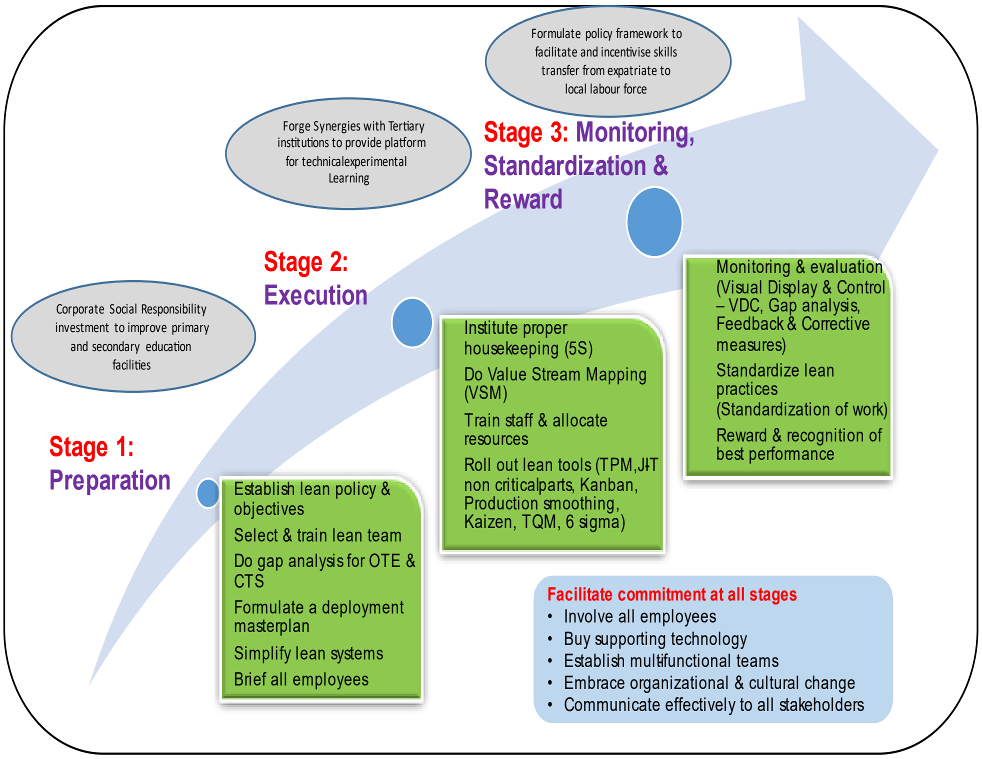

Figure 6-1: Lean Framework

The developed lean implementation frame has three stages: the preparatory,execution and the post-implementation stage. There is a need to ensure commitment to successfully implement the framework throughout the three stages. The three-staged framework agrees with the lean implementation framework proposed for Small to Medium Enterprises (SMEs) by Belhadi and Touriki (2016). This approach provides a systematic approach to implementing the lean framework. Earlier on, Nordin et al. (2012) proposed a staged approach. However, their framework had two major categories: readiness for change and implementation of the change. Despite the different stages, the underlying principle is that companies must embrace a new way of doing things when implementing a lean framework. The analysis below further investigates each stage and provides an in-depth assessment of the suggested action items.

6.5.1 Preparation Stage

This initial stage sets the foundation for adopting and applying the proposed lean implementation framework for the Mozambican sugar factories. As a starting point, a factory should ensure that it has established a clear lean policy and accompanying lean objectives. The lean policy provides a clear direction of the envisaged roadmap to pursuing the lean implementation framework. Also, the lean goals should be spelt out to establish the milestones the factory will seek to attain. The lean policy and objectives should align with the company strategy and goals. This agrees with Sarkis and Talluri (2002), who opined that a successful lean framework implementation must include an organisational strategic plan, among other things. Nordin et al. (2012) underline that management should show their strong intent to implement the lean framework by setting a clearlLean policy and objectives aligned with the factory's strategic global policy. Also, goal setting guides the efforts of the organisation’s strategic programmes in line with the firm's vision and strategic intentions (Gözaçan and Lafci, 2020).

Moreover, the lean policy should establish the assessment benchmarks used to evaluate the effectiveness of the lean implementation framework. Benchmarking in lean implementation was observed to improve performance, quality and overall competitiveness (Comm Clare and Mathaisel Dennis, 2000). Furthermore, benchmarking enables the organisation to pursue continuous improvement practices, which is one of the lean tools. This augurs well with Ralston et al. (2001) findings. Equally important is selecting a group of employees who will spearhead the lean framework implementation. It is imperative to choose a diverse and cross-functional team to ensure that such individuals can meet the various demands of the implementation. Moreover, the team should be able to assimilate and articulate issues from a global perspective together with being able to provide the required leadership. The team should be trained on the lean principles and policies. They should fully understand the finer details of lean implementation framework because their mandate extends to providing guidance to the rest of staff that wiould be executing the framework. In addition, part of the lean teams’ roles include the following:

- Carrying out a gap analysis for the identified major efficiency measures or key performance indicators, namely the OTE and the CTS ratio. The gap is established by comparing the current performance with the benchmarks provided by the lean policy above. Along with implementing the lean framework, the gap is continuously monitored, and the lean objectives should target to close the established gap. This is echoed by DE LA GESTIÓN (2020), who underlined that goals and key performance indicators should be selected to help achieve a company's strategic intent.
- Formulating a deployment master plan. The master plan includes clear action plans for executing the lean framework. The selected lean team is mandated to develop an implementation blueprint to guide participants on what to do, when and how to do it. Planning for deployment agrees with Sarkis and Talluri (2002), who suggested that a strategic organisational plan supported by detailed action plans leads to a successful framework implementation.
- Simplify lean systems and procedures. Lean implementation has some technical aspects that may not be easily assimilated by all employees, thus, the proposed Lean framework mandates the lean team to ensure that implementation prescriptions are unambiguous and easy to understand. In Mozambique, simplification entails translating the lean framework into local languages, including Portuguese, Changana and Sena. This prevents language barriers.

Lastly, in Stage 1, management and the lean team should ensure that all employees across the factories have been briefed about the implementation framework to be pursued. Such briefings enhance staff buy-in and remove the emergence of ambiguity. Also, employees should ask questions to ensure they fully understand what is intended to be achieved. It is also critical to highlight the lean objectives, existing gaps, bridge the gap, the advantages and rewards upon closing the gap. Overall, the actions suggested under the Lean implementation framework's preparation stage are sound and ensure that a factory has a strong launch pad to implement the same. This is in concordance with Nordin et al. (2012), who suggested that companies must ensure that all necessary foundations have been put in place to implement lean frameworks successfully.

6.5.2 Execution Stage

The second stage is the execution stage, where the factory implements the Lean framework to improve the overall efficiency as measured by OTE and CTS ratios. This stage operationalises the lean implementation principle by applying the various lean tools. Firstly, a company should ensure there is proper housekeeping across the factory. This is achieved by applying the 5S lean tool, where 5S stands for sort, set in order, shine, standardise and sustain. Housekeeping puts things in good order, making subsequent lean actions easier to execute. This resonates with Lee (2004), who suggested that the first effective practice in lean implementation is a robust 5S programme. After that, the factory should carry out a VSM, a lean tool that enables the factory to identify their unique wastes that pull down the efficiency measures of interest (OTE and CTS). VSM results reveal the areas of focus for the subsequent lean tools. For instance, if VSM identifies that plant breakdowns are rampant, increasing the factory's OTE, a lean tool like (TPM) can be pursued to reduce the downtime due to plant breakdowns. The use of VSM to identify waste was also postulated by Nallusamy and Ahamed (2017), who established that VSM is vital in determining types of manufacturing wastes and means to reduce or eliminate these wastes. Similarly, Rohac and Januska (2015) opined that value stream mapping helps to make small but continuous improvements, aiding the overall performance of any organisation.

Having identified wastes endemic within a factory, the lean team should educate all employees and facilitate appropriate resource allocation. Education entails training all employees on lean practices, identified wastes and lean tools that should be used to reduce the identified wastes. Furthermore, training prepares the employees to embrace any changes that may be brought by implementing the lean framework. This agrees with Nordin et al. (2012), who opined that training of all employees orients the shop floor workers to have a sense of ownership and responsibility of the implemented lean practices. Furthermore, they added that trained employees are more willing to embrace change. Without adequate resourcing, the lean objectives may be in danger, thus, factories should ensure that time and physical resources have been duly provided to all employees implementing the lean framework.

At this stage, all employees will be ready to roll out the lean tools to remedy the set of identified wastes within their factory. Based on the overall sugar factory wastes identified when developing the lean implementation framework, seven lean implementation tools have been proposed. These tools spectrum provides a wide variety of ammunition to remedy wastes commonly found in the sugar factories. The seven lean tools are:

- Total productive maintenance (TPM): optimizes the reliability of the manufacturing plant and equipment. TPM reduces plant and equipment breakdowns, as well as safety challenges. It combines productive and predictive plant maintenance by appropriately considering equipment maintenance per design requirements. Also, TPM enables employees to treat the plant and equipment as their own; thus, they are geared to suggest better maintenance strategies. This agrees with Gunasekaran (1998), Kumar et al. (2006), and Ondiek and Kisombe (2012), who observed that TPM improves the overall factory efficiency by reducing downtime due to plant and machinery breakdowns.
- JIT for non-critical parts recognises that Mozambique has locational challenges, thus, critical spare parts take a long time to be received. JIT can manage, however non-critical parts. JIT for non-critical parts entails only having necessary parts at the right time, thereby reducing costs. This agrees with Karlsson and Åhlström (1996), who observed that just-in-time flow reduces in-process inventories, thereby eliminating waste due to unnecessary inventory, which takes up valuable and costly space.
- Kanban is a Lean tool that enhances the execution of lean principles by signalling information on the number of products, where the product is coming from and its destination. Kanban ensures appropriate signalling along the manufacturing process, thus the required quantities of products are manufactured at the right time.The process applies to inputs and outputs along the sugar manufacturing process.Therefore, Kanban aims to reduce inventory and overproduction, and it also improves the manufacturing process flow by removing chances of bottlenecks. The factory's responsiveness to changes in demand is also enhanced, thus empowering the factory to manage its supply chain. The benefits of Kanban

agree with those observed by Hobbs (2003) that inventory will be reduced, thus increasing the efficiency of an organisation.

- Production Smoothing (PS) is a tool that implies levelling the production quantities to equal the demand quantities over time, thereby reducing inventory and overproduction.
- Continuous Kaizen entails the factory consciously instituting continuous and comprehensive improvement to the sugar manufacturing process. Kaizen should be small, incremental, nonstop and complete improvement throughout the sugar process. All employees should drive continuous Kaizen by promoting cross-functional and multi-skilled teams. Thus, through Kaizen, a factory improves its level of leanness by systematically identifying and eliminating non-value-adding activities.
- Total Quality Management (TQM) is a lean tool that improves sugar quality by continually improving the sugar processes through valuable employee feedback. This agrees with Khurram and Hashmi (2006), who suggested that TQM enhances product quality by pursuing customer satisfaction, continuous improvement, total quality control, and employee training. Thus, like Ondiek and Kisombe (2012), apart from increasing product quality, TQM increases the efficiency and productivity of a company.
- Six Sigma is a systematic method that employs DMAIC (define, measure, analyse, improve and control) to improve manufacturing processes. Six Sigma reduces variations and defects along the process line. It also reduces human error and system failures, thus increasing the efficiency of a factory. These observations coincide with Trimarjoko et al. (2020), who noted that six sigma reduces human, system transactional errors and non-value added activities.

6.5.3 Monitoring, Standardisation and Rewards Stage

This stage has three significant aspects: monitoring, standardisation and a reward regime for best performers. Though monitoring is put in stage three, monitoring is a continuous process transient through lean implementation. Monitoring requires installing necessary measuring equipment and visual display units to track performance. Sugar factories can use a visual display and control (VDC) lean tool that enables everyone to quickly understand what is going on in the plant. VDCs act as a dashboard that tracks the plant's key performance measures and safety details. This is in line with Ondiek and Kisombe (2012) suggestion. After getting records of KPI, the factory should carry out a gap analysis between the target benchmark and the observed KPI. The gap analysis will reveal whether the lean tools yield positive or negative results. Also, should there be any need for corrective measures to be taken, the feedback mechanism would relay the same to the appropriate section of the plant.

Worker actions need to be standardised to avoid a haphazard approach to implementing lean principles.Standardisation entails that each process and procedure is well organised to be done most effectively. Takt time is a tool that is used to standardise work where takt time is the available production time per day, divided by customer demand per day. Thus, the target is to produce sugar at a pace not more than the takt time for sugar.

Lastly, factories implementing lean frameworks should have a system to reward the best lean performers to encourage employees' best participation. The reward regime can be financial or non-financial, and it is set in the lean policy in the preparatory stage. Once the policy is in place, execution should be transparent and fair to avoid evoking negative energy among employees.

6.6 Chapter Conclusion

This chapter presented the discussion of findings to meet the study's objectives. A Lean implementation framework was developed and validated by the experts. Having met these objectives, the study chose a Mozambican sugar factory to test the framework's impact on them. The next chapter outlines findings from the framework in-field evaluation.

CHAPTER 7:

THE QUANTITATIVE STUDY RESULTS (PHASE 2 - FRAMEWORK EVALUATION)

7.1 Overview

The answer the fourth and final research question an evaluation of the impact of the proposed lean implementation framework on improving sugar processing efficiency in Mozambique was conducted. The evaluation was done through a case deployment of the developed implementation framework at AD Sugar Factory. Although framework validation was done through expert opinions, it was necessary to further evaluate and validate it through infield test application. The case study entailed a full implementation of the proposed framework. Through observations and feedback from selected participants, answers to the question regarding the impact of the proposed framework on the sugar factory's efficiency were established. Also, remarks on the challenges and easiness of implementing the framework were sought to enable the study to recommend an appropriate systematic framework to improve efficiency for sugar factories in Mozambique.

7.2 Background Information for the Selected Case - AD Sugar Factory

The AD sugar factory was selected among Mozambique's sugar factories as it fit well in the criteria outlined in the methodology case selection section. The factory is the largest sugar milling factory in Mozambique and processes sugar for local and export demand. The factory is strategically located, close to the port and neighbouring South Africa. In 2019, the AD sugar factory produced about 180,000 tons of sugar and ought to continue improving its output by addressing any inherent inefficiencies to compete in the global market, especially post preferential trade agreements. The sugar factory is supplied by vast irrigated cane fields that ensure a 32-week sugar production per year and employs more than 700 seasonal and permanent employees. The sugar factory was upgraded from 4000 to 9000 TCD in the year 2009/10. While the expansion was right for the organisation, several layouts, human capital, capacity utilisation, and process capabilities were among many other issues generally associated with most brownfield projects. These lead to technical inefficiencies and ultimately increased production costs and loss of potential revenue for the business.

7.3 AD Sugar Factory Adopting and Deploying the Lean Implementation Framework

7.3.1 Stage 1 - Preparation Stage

This was the first stage in implementing the proposed Lean framework for sugar factories in Mozambique. Firstly, the AD Sugar Factory's top management was engaged in extensive discussions on how the lean framework is designed to remedy inefficiencies in sugar processing factories. The top management understood the value of implementing the framework, which set a foundation for implementation due to top management buy-in. Such buy-in enabled lean implementation to have appropriate support from the top echelons and the commitment to facilitate all the requirements to ensure the framework's success. Furthermore, management emphasised that the framework should result in cost-effectively improving efficiencies, thus, the cost of implementing the framework should be overwhelmed by its benefits. They also underscored the need for clear objectives and simplified rollout plans to ensure easy adoption by the staff members.

The top management engagement resulted in formulating and adopting the Lean policy and broad objectives. AD's lean policy provided the purpose of the policy, definitions of the lean and the framework, an outline of lean principles and tools, roles and responsibilities, risk control and SHEQ, how monitoring and reporting are done, who is responsible for the lean policy and who should comply with the policy. Lastly, the lean policy provided how it should be adopted, approved and reviewed to remain relevant as time goes on. Also, discussions with the top management yielded the following broad lean objectives:

- To implement the lean framework to improve factory efficiency by reducing the gap between KPIs and industry best standards.
- To select a lean framework steering team that shall:
    - Oversee the lean framework implementation by formulating and executing a deployment master plan.

    - Do gap analysis for OTE and CTS together with the supporting process performance indicators against the industry standard.
    - Brief and train other employees.
    - Facilitate availability of required resources.
    - Facilitate implementation feedback.
    - Monitor performance indicators and report findings to top management and all employees.
    - To standardise processes and procedures to lean principles.
- To effectively communicate at all levels.
- To recognise and reward employees' lean framework implementation performance.

The objectives guided deliverables in the lean framework implementation. The lean steering team (Lean team) comprised twelve members: six operation supervisors, two process engineers, two maintenance engineers, and two senior managers. The constituents of the lean team covered the factory's departmental spectrum and selected members at the appropriate level of authority. The lean team underwent training on lean principles, tools, the proposed framework, and the lean policy formulated by the AD sugar factory. The training was in the form of a train-the-trainer format, which enabled the team members to grasp the lean fundamentals and the proposed framework, with the hope that they would be able to teach other employees.

After establishing a firm, lean and framework understanding, the lean team carried out an efficiency gap analysis at the AD sugar factory. The team acknowledged that the primary efficiency measures for a sugar factory are OTE and CTS. However, they averred that various performance measures and sugar processing feed into these two significant efficiency measures. The team opined that it is critical to consider and monitor these supporting performance measures to avoid delaying intervention initiatives, should a localised block performance go south. In line with this, the lean team performed a gap analysis on the supporting key performance indicators under each processing block over and above the recommended OTE and CTS measures. Table 7-1 provides the gap analysis results that depict the following: key performance measure, benchmark, actual before lean implementation, gap and standards (either referenced to empirical prior research reference or regional best measure in the past four years, see Appendix I).

Table 7-1: Key Performance Measures Gap Analysis Before Framework Implementation

Block/Item	KPI	AD Before	Benchmark	Established Gap**
1. Cane preparation	Burn to Crush (BTC)*	67.2 hours	≤12 hours	-55.2 hours
	Pol % Cane (CQ)	13.60%	≥15.35%	-1.75%
	Preparation Index (PI)*	91.20%	≥92.00%	-0.80%
2. Juice extraction	Extraction	96.10%	≥98.17%	-2.07%
	Pol % Bagasse (BL)*	1.70%	≤0.60%	-1.10%
3. Sugar production	Pol % Filter Cake (FCL)	10.20%	≤0.05%	-10.15%
	Boiler House recovery (BHR)	84.30%	≥91.16%	-6.86%
	Final Molasses Loss (FML)	4.60%	≤7.13%	+2.53%
	Undetermined Losses (UL)	4.50%	≤0.10%	-4.50%
	Overall Recovery (OR)	81.10%	≥88.18%	-7.08%
4. Major Efficiency measures	Overall Time Efficiency (OTE)	83.10%	≥98.79%	-15.69%
	Cane to Sugar (CTS)	9.00	≤7.58	-1.42%

** Benchmarked to the relevant empirical literature. The rest are benchmarked to SADC's best.*

*** - sign mean AD's actual is worse than benchmark and + sign mean AD's actual is above benchmark.*

The lean team crafted an implementation blueprint. Since the team was formulated by getting representation from each of the key departments at AD, the members became trainers and ambassadors for lean implementation in their respective departments. However, firstly AD's Managing Director briefed all employees at a staff address of the company's intention to implement a lean framework to improve efficiency. The managing director highlighted the existing efficiency gaps, the need andbenefits of improving the same. Employees were also advised that the lean ambassadors would carry out detailed training on lean implementation. Such a brief ensured that all employees got the message of intent from the AD sugar factory's highest office and became aware of the advantages of implementing theframework. The team concluded the preparatory stage by ensuring that the implementation training resources have been well documented in simple language, accompanied by appropriate visual aids. In some instances, the team infused some role-plays and concluded individual assessments in the training schedule to ensure that employees fully understood. It was emphasised that employees were free to seek clarifications at any time, and the company established a lean framework implementation office endowed with the resources for that purpose. It was physically accessible to all employees and was furnished with well-managed electronic communication channels.

At AD Sugar Factory, the top management support and involvement were critical to achieving success in adopting and deploying the resources. Once the management buy-in was achieved, forming a heterogeneous cross-functional team in the lean steering team became easier. Lean implementation requires valuable employee input, and cross-functional steering teams are critical for success (Coetzee, 2019). The drive and briefing from AD Sugar Factory's Managing Director added weight to the cause of the implementation, while providing the much-needed financial resources to implement the framework. It was observed at AD sugar Factory that the need to deploy lean resonated across all operations levels after the top management's training and involvement. This finding is supported by various authors- Grove et al. (2010), who noted that stakeholder and top management buy-in is a crucial requirement for a successful deployment of a lean initiative.

Benchmarking exercises done at the AD Sugar Factory revealed that the main efficiency measures of OTE and CST lag similar operations in the SADC region by 15.69% and 1.42%. The team further established gaps in the other nine sub-efficiency measures. However, they focused their efforts on the main efficiency measures OTE and CTS, identified by the proposed implementation framework. The identified gap helped to give direction and assisted in quantifying possible gains and improvements.

7.3.2 Stage 2 - Execution Stage

7.3.2.1 Training and Awareness

Ahmed et al. (2020) underscore that in most lean implementation failures, the lack of training and awareness has been identified as the primary root cause. All stakeholders, including the implementation drivers, are engaged, skilled and ensured alignment at this framework stage. Business case, smart goals and key performance indicators are shared during this step to align process understanding and the need for the change. At this step of the framework, potential challenges and concerns that lay ahead are discussed with various stakeholders and mitigation is sought, with input from all employees, managers and customers alike. Yahya et al. (2019) guarantee that training and awareness are done before lean implementation results in higher productivity, efficiency and quality. Ralston et al. (2001) support this finding by reasoning that in today's global economies, for the organisation to compete, they must major in building their competencies and this is achieved through training and development.

The AD sugar industry had already implemented 5S, a housekeeping tool on the lean framework stage two. All departmental managers confirmed that they successfully implemented 5S principles; hence sugar processing was carried out in a pristine and orderly environment. Then the lean team trained all AD sugar factory employees and selected other stakeholders on the implementation framework. Table 7-2 summarises focus areas, key performance indicators and training interventions.

Table 7-2: Training and Awareness Intervention Matrix

	Performance Gap	**Applicable Key Performance Indicator**	**Training and Awareness Interventions**
AD Factory Suppliers and Customers	Efficiencies, Productivity	Overall Time Efficiency	Supplier and customer engagement; monthly meetings; electronic communication; social media
AD Factory Cane Supply	Efficiencies, Productivity	Burn to Crush delay, Pol % Cane, Preparation Index	Stakeholder Training, awareness, and brainstorming; daily meetings; awareness through social media; weekly newsletter
AD Factory Employees and Management	Market share, Efficiencies, Productivity	Burn to Crush, Preparation Index, Extraction, Overall Recovery, Boiling House Recovery, Pol % Bagasse, Final Molasses Loss, Undetermined Losses, Pol % Filter Cake, Pol % Cane, OTE & CTS	Employee & Management Training, awareness and brainstorming; Regular meetings, weekly newsletter, daily notice boards, suggestion boxes; use of social media

Stakeholders participated in the training programmes that were rolled out as per the training needs matrix table above. A monthly newsletter was launched, with content covering safety, operations key performance indicators, targets and other operations strategic objectives, as set out by the AD Sugar Factory Senior Management team. Competitions and quizzes to promote awareness were also launched across the organisation, with results published monthly in the AD Sugar Factory Newsletter. Notices were posted on the notice boards to include awareness information such as organisation and operational targets. Stakeholders were encouraged to give their inputs by providing suggestion boxes at various points in the operations and feedback. Social media platforms were created to capture imported inputs from the organisation's internal and external stakeholders. The awareness drive was done for three consecutive months to ensure the information reached the targeted population.

Various stakeholders understood the organisation's direction through the training and awareness programmes or interventions. There was a great common understanding of where the organisation was positioned in the global context for employees and managers. Again, the motivation for the improvements that were made clearer for both parties. A survey was carried out to measure common stakeholders improved understanding and alignment at AD sugar factory. An acceptable response rate of 72% was achieved, which is well within the recommended return rate. Testing the instrument's reliability was done by calculating the Cronbach alpha of the instrument. According to Hulin et al. (2001), a Cronbach alpha of between 0.5 to 0.9 is acceptable, and this acceptance alpha range was adopted for this study. Two sets of samples were done to find awareness levels of the same participants before and after training. Therefore, Cronbach alpha was calculated for the two separate data sets. Excel 365 data analysis tool pack was used for data analysis, and Table 7-3 summarises the observed statistics.

Table 7-3: Summary of Statistics for the Before and After Training

Statistic	Before Training[a]								After Training[b]							
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Mean	2.22	2.07	2.28	2.35	2.61	2.56	3.34	2.76	2.79	2.64	3.22	2.93	3.06	2.88	3.61	3.01
Median	2	2	2	2	3	2	4	3	3	3	3	3	3	3	4	3
Mode	2	2	2	2	3	2	4	3	3	2	3	3	3	3	4	3
Std Dev	0.95	0.72	0.86	0.67	0.74	0.90	0.77	0.76	0.73	0.76	0.65	0.76	0.69	0.79	0.62	0.80
Minimum	1	1	1	1	1	1	2	1	1	1	1	1	1	1	2	1
Maximum	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Sum	160	149	164	169	188	184	237	196	201	190	232	211	217	207	260	217
Count	72	72	72	72	72	72	71	71	72	72	72	72	71	72	72	72

a – Cronbach alpha 0.64 b – Cronbach alpha 0.60

The results show the least total score for questions two and eight, before and after training ranking. A general increase has been noted across the different constructs from before to after training and awareness.

7.3.2.2 Training and Awareness (Alignment) Results Analysis

Descriptive statistics showed an alignment improvement following the training interventions instituted. Statistics showed that after training, the means were all greater than the corresponding means before training. Medians and modes remained flat on a few questions, but posted a positive increase on many questions. Furthermore, the totals on all questions increased when comparing sums for before and after training. Hence, overall, it was observed that the descriptive statistics for individual questions suggested an improvement in alignment amongst stakeholders. Alignment in this context meant the same understanding of the organisation's performance gaps and key performance indicators required to close or reduce the performance gap. Notably, all stakeholders agreed on the need for performance improvement.

Further analysis of the total score per participant was conducted to facilitate statistical tests to establish whether the two responses, namely before and after training, were significantly different. Firstly, the descriptive statistics for the participant total scores were contrasted and secondly, a t-test was done to establish the significance of the differences. Also, it was essential to determine whether the increase in the level of alignment before and after was not random or chance. Hence, inferential statistical test analysis was employed. A t-test for paired two sample means was chosen, and it was carried out using the IBM SPSS Statistic 27 to answer if there was sufficient evidence to suggest that the mean score of awareness is greater after training on the KPI and performance gap, than before training. The total scores per participant were analysed using a paired t-Test. Table 7-4 summarises the findings of the two analyses.

Table 7.4: Summary of Total Score Measures and T-Test Results

Statistic	***Before Training***	***After Training***
Mean	20.10	24.10
Median	20	24
Mode	20	22
Sum	1447	1735
Observations	72	72
Pearson Correlation	0.53	
Hypothesized Mean Difference	0	
Df	71	
t Stat	-10.84	
P(T<=t) one-tail	5.22E-17	
t Critical one-tail	1.667	
P(T<=t) two-tail	1.04E-16	
t Critical two-tail	1.994	

Comparing the samples reveals that the mean, median and mode of the total scores increased in the second sample. Furthermore, the sum of scores for alignment increased from 1447 to 1735, before and after training and awareness intervention, respectively . This represents a total alignment level of 288 score points after implementing the training step of the proposed lean implementation framework. As shown in Table 7-4, the t-Test produced a probability of 5.22E-17, which was less than the critical-one-tailed test point for the 95% confidence level test of 1.67. Also, the t-Test had a probability of 1.04E-16, which was less than the critical-two-tailed test point for the 95% confidence level test of 1.99. Therefore, it was concluded that the difference in the level of alignment before and after training and awareness interventions was statistically significant. It was reasonable to suggest that training and awareness improved AD Sugar Factory's employees' alignment with its objectives and lean framework.

7.3.2.3 Waste Identification (Value Stream Mapping Quantitative Results)

After the training, the lean steering team, a collection of employees across different levels, spearheaded a waste identification exercise for the AD sugar factory through the Gemba methodology. The results of waste identification from the selected participants are shown in Table 7-5. A table with the eight wastes identified in the literature was developed. A group of nine engineering and processing managers and supervisors were purposively chosen and requested to rank the wastes per section, along the production line. This was done to set the basis of lean manufacturing principles and tools to reduce and eliminate existing waste. Table 7.5 presents the combined AD sugar factory waste rating results. The outcome from the survey showed motion and waiting time, as 19% and 18% contributors to the total waste found at the AD sugar factory, respectively. Transportation, defects and talent waste follow the list of significant contributors to lean waste.

Table 7-5: AD Sugar Factory Waste Rating Results

Process Description	TA	MO	TR	IN	WT	OD	OP	Def
Truck Calling	4	13	7	2	15	2	0	1
Truck Weighing	3	10	6	1	9	0	0	0
Cane Loading Off Loading	8	19	12	3	14	4	0	7
Cane Preparation	12	18	18	11	12	3	3	11
Juice Extraction	12	19	17	5	12	6	1	13
Milling (dewatering)	10	17	14	6	12	0	0	14
MJ Weighing, Storage and pumping	7	6	5	2	5	3	4	7
Clarification	6	8	6	5	3	3	0	11
Mud Return	0	6	5	1	7	1	1	9
Clear Juice Heating	5	6	6	3	10	0	0	9
Evaporation	3	11	8	4	17	1	1	11
Crystallisation	9	16	9	8	17	4	2	15
Curing	5	13	10	7	18	8	3	12
Raw Sugar Conveying	3	12	12	5	13	2	0	11
Prepack ffs	19	23	25	15	22	8	1	17
Bailer machine	18	18	19	8	20	8	1	15
Packed product conveying	12	15	23	14	15	7	1	17
Warehouse stacking and Storage	13	19	21	7	16	21	10	14
Warehouse Dispatching	15	17	21	7	15	16	9	12
Industrial Stores	11	13	10	20	14	8	0	12
Total Score	**175**	**279**	**254**	**134**	**266**	**105**	**37**	**218**
Relative percentage	12%	19%	17%	9%	18%	7%	3%	15%

TA- Talent, MO – Motion, TR – Transportation, IN – Inventory, WT – Waiting Time, OD – Overproduction, OP – Overprocessing and Def – Defects

Table 7-5 revealed that AD Sugar Factory's wastes along the production line are motion, waiting, transportation, defects, talent, inventory and overproduction in their decreasing order. The motion wastes involve inefficient workspace design, leading to employees taking too much time walking between workstations while executing their duties. Waiting, on the other hand, was primarily due to equipment breakdown. Defects waste took the form of out-of-specification KPIs per section. Transportation waste for the factory entailed moving products over long distances, especially for product storage. Underutilisation of talent due to a lack of cross-functional or multiskilled work teams was also noted from the responses of subject experts. Inventory waste constituted 7% of the total AD Sugar Factory wastes, as classified by the participants.

With the waste classifications identified, lean principles and tools were matched to reduce or eliminate the identified waste. For AD Sugar Factory, the following lean manufacturing principles were applied: value stream identification, production flow, pull mechanism, the pursuit of perfection and specification of customer value. The five lean manufacturing principles and the following lean manufacturing tools were applicable for AD sugar factory: 5S, root cause analysis, total productive maintenance, standardisation, just-in-time, kaizen, multi-skilling and customer involvement.

7.3.2.4 AD Sugar Factory Value Stream Mapping

As stipulated by the proposed implementation framework, the AD sugar factory conducted a VSM as part of the execution stage. This VSM established the current state map from which improvement opportunities were identified and mapped to a suitable Lean tool. As alluded to in the literature, this step aims to eliminate waste and improve processes to achieve the set goals and key performance indicators. The VSM was mapped and drawn up from the observations and discussions with senior operating staff during the Gemba walk conducted by the Lean implementation steering team. The results are presented in Table 7-6 , duly classified as value-adding (VA), necessary but non-value-adding activities (NNVA), or non-value-adding activities (NVA).

From this mapping, step outputs include activities which are classified as NVA (Non-Value Adding) - 24%, NNVA (Necessary Non-Value-Adding Activities) – 20%, and VA (Value-Adding Activities) – 56%. Improvement opportunities arise from eliminating non-value-adding activities, which account for 24% of the product lead time or product processing time, effectively equating to 4.9hrs per unit ton of sugar produced and packed. With these opportunities captured, a future state mapping commences, reflecting the desired state with less processing time. Thus, a future mapping exercise is a process state in which all non-value-adding activities are eliminated, while processing time and cost are also reduced.

Table 7-6: Production Process Analysis of Current State

Process Activity	Time (min)	Classification
Waiting in the Park Yard	71	NVA
Cane truck Enter the Weighbridge for capturing the weight	10	VA
Offloading at spiller	30	NNVA
Cane transported by C1 Conveyor to C2 conveyer	25	NVA
Cane pre-preparation (knives)	5	VA
Cane transported by C2 Conveyor to C3 conveyer	10	NNVA
Cane preparation (hummers)	5	VA
Cane transported by C3 Conveyor to C4 conveyer	5	NNVA
Cane transported by C4 Conveyor to C5 conveyer	5	NVA
Cane transported by C5 Conveyor to C6 conveyer	5	NVA
C6 conveyer feed the diffuser for extraction - 97.1% target	90	VA
Cane discharged into M1 and taken to Mill 1	1	NNVA
Mill 1 to M2 conveyor	1	VA
M2 conveyor to Mill 2	1	VA
Mill 2 to B1 conveyor	1	NNVA
M2 to M3 conveyor	1	NNVA
M3 conveyor to Mill 3	1	NNVA
Mill3 to B2 conveyor	1	NNVA
B1 conveyors to B3 conveyor	1	NVA
B2 conveyors to B3 conveyor	1	NVA
Drying the bagasse (Mills) <50% moisture	5	VA
MJ Scale weighing	5	NNVA
Juice Heating- Mixed juice inlet temperature on Juice heaters - (55ºC), and outlet temp - 105ºC	15	VA
MJ Tank storage	15	NVA
Clarification to remove all the suspended solids	58	VA
Evaporation (water removal) - inlet brix 13%, outlet brix 65%,	60	VA
Clear Juice Tank	30	NVA
Steaming Tank	60	NVA
Clear juice heating	15	NVA
Crystallization - crystal formation	360	VA
Curing - crystal, and mother liquor separation through centrifuge force	5	VA
Drying - moisture removal (from 1% to 0.08%)	20	VA
S8 takes the sugar to vibration screen or silos	10	VA
From vibration screen to distribution (1 kg (prepack), 50Kg, and 1Ton)	5	NNVA
Sugar Bins	30	NNVA
Sugar Packing	20	VA
The W2 conveyer takes 20Kg ballers and 50 Kg Bags to store and dispatching area	5	NNVA
Stores receive the bags on the W3 conveyer and arrange it into the slings	5	NVA
From here is loaded into the truck 50 KG slings and 1Kg ballers	120	NNVA
The truck goes out right the weighbridge for confirmation of the weights	20	NNVA
Excess sugar goes to warehouses 3 to 9, depending on specifications	60	NVA
Total	**1193**	

The current state mapping is a direct result of observations made by the steering team for the framework implementation committee during the Gemba Walk. The observations were verified through an in-depth confirmatory discussion with AD factory senior operating teams to ensure the observations reflected the normal work processes. Table 7-7 provides the production process analysis of the future state.

Table 7-7: Production Process Analysis of Future State

Process Activity	**Time (min)**	**Classification**
Cane truck Enter the Weighbridge for capturing the weight	10	VA
Cane pre-preparation (knives)	5	VA
Cane preparation (hummers)	5	VA
C6 conveyor feed the diffuser for extraction - 97.1% target	90	VA
Mill 1 to M2 conveyor	1	VA
M2 conveyor to Mill 2	1	VA
Drying the bagasse (Mills) <50% moisture	5	VA
Juice Heating- Mixed juice inlet temperature on Juice heaters - (55ºC), and outlet temp - 105ºC	15	VA
Clarification to remove all the suspended solids	58	VA
Evaporation (water removal) - inlet brix 13%, outlet brix 65%,	60	VA
Crystallization - crystal formation	360	VA
Curing - crystal, and mother liquor separation through centrifuge force	5	VA
Drying - moisture removal (from 1% to 0.08%)	20	VA
S8 takes the sugar to vibration screen or silos	10	VA
Sugar Packing	20	VA
Offloading at spiller	30	NNVA
Cane transported by C2 Conveyor to C3 conveyor	10	NNVA
Cane transported by C3 Conveyor to C4 conveyor	5	NNVA
Cane discharged into M1 and taken to Mill 1	1	NNVA
Mill 2 to B1 conveyor	1	NNVA
M2 to M3 conveyor	1	NNVA
M3 conveyor to Mill 3	1	NNVA
Mill3 to B2 conveyor	1	NNVA
MJ Scale weighing	5	NNVA
From vibration screen to distribution (1 kg (prepack), 50Kg, and 1Ton)	5	NNVA
Sugar Bins	30	NNVA
The W2 conveyer takes 20Kg ballers and 50 Kg Bags to store and dispatching area	5	NNVA
From here is loaded into the truck 50 KG slings and 1Kg ballers	120	NNVA
The truck goes out right the weighbridge for confirmation of the weights	20	NNVA
Total	**900**	

With the future mapping, the per-unit production and processing time has dropped significantly from 1193 minutes to 900 minutes. This decrease in processing time meant fewer activities were done to achieve the same amount of sugar output, thereby contributing to the overall efficiency of the sugar manufacturing entity. Implementing VSM at the AD Sugar Factory indicates unnecessary gaps in the processing line and does not add value to the final product. These no value-adding activities, if not eliminated, lead to a higher unit cost of the final product. As the proposed framework seek to make the sugar industry in developing countries competitive after the withdrawal or expiry of the preferential trade agreement with the European Union, the framework step of VSM identifies waste in the production line, for reduction and eventual elimination. The lean tool VSM gives a pictorial looking ahead view in the form of a future state map. This step of the framework establishes goals for production cost reduction by reducing waste in the sugar processing line.

7.3.2.5 Improvement of Production Flow

The Lean team implemented the lean tools by applying the Lean principles to address the identified wastes. The team pursued a lean principle called improvement of production flow. This principle sought to reduce the time taken by wastes such as motion and rejects, leading to higher chances of meeting the set key performance indicators for the processing entity. Five lean tools were selected from the literature and applied to improve production flow at the AD Sugar factory. The five tools include 5S, standardisation, total productive maintenance, root cause analysis (RCA), and just in time. Employees had been initially trained on lean principles during the training phase. However, refresher training per department was done. After that, monthly lean compliance inspections and audits were adopted to enhance lean tools and principles implementation. Competitions on compliance competitions ensued, focusing on resolved engineering breakdowns (RCA) and maintaining workplace order (5S). These interventions cemented the acceptance and practice of targeted lean principles and tools. In addition, workplace written work instructions and KPI boards were erected in each work centre. These interventions enabled a uniform standardised way of operating the processing line, ensuring reduced defects while enhancing efficiency. AD sugar factory implemented a computer-based maintenance system (CBMS) to auto-generate maintenance schedules to achieve higher equipment availability. A computer-based maintenance system helped enforce a robust total productive maintenance lean tool to improve equipment availability. The effective implementation of the CBMS at AD Factory has gaps that can be closed by engaging suitably skilled employees in the reliability section of their manufacturing operations.

7.3.2.6 Pursuit of Perfection

The third lean principle identified as essential to meeting AD Sugar Factory objectives was to embed a culture and drive for the pursuit of perfection. The pursuit of perfection principle recognises that perfection is a destination that can never be reached. Therefore, when an organisation continuously seeks to get to this ever-moving target destination, it gets better and better. To realise the established key performance indicators for AD sugar Factory, the organisation continuously pursued perfection in its operation and processes. By so doing, the organisation maintained the energy needed to sustain the lean philosophy initiatives. The lean implementation package best achieves perfection where lean tools called Kaizen, and cross-functional teams' practices, can be employed. The AD Sugar Factory adopted Kaizen and cross-functional teams to pursue perfection continuously.

As noted in the literature, Kaizen entailed continuous small incremental improvements leading to a desirable culture of unending pursuit of perfection. Adopting the kaizen tool and way of doing business was further ingrained in the organisational culture by establishing operation improvement suggestion boxes. Prizes were handed to winning employees whose improvement initiatives were adopted and implemented. Also, employees with the highest contributions were rewarded, even though their ideas may not have been implemented.

With the cross-functional teams, AD Sugar Factory sought to move employees around the factory operations to give a new view and perception of the operations. A multi-skilled workforce enabled employees to do different kinds of work across the processing line. As a result, the employees covered for each other in the event of justified or unjustified absenteeism. For AD Sugar factory, cross-functional teams helped employees to understand a wider operational area and the complete value chain along the processing line. With this understanding came innovative, wholesome ideas and processing work efficiency for the organisation. The positive impact of cross-functional teams observed on the AD Sugar Factory is in line with the conclusion by Pakarinen and Virtanen (2017) that cross-functional teams improve internal coordination and improve organisational performance. However, one challenge that became very clear at AD is the lack of industry-specific skills and generally lower-than-required literacy levels to function effectively in cross-functional teams.

Still under the pursuit of perfection on the model, an inventory management system named Kanban was adopted along the processing value chain at AD Sugar Factory. Kanban was implemented in the different sections where inventory is an integral part of the process. The implementation targeted reducing and eliminating inventory waste caused by stock-outs or excessive inventory. In their experimental study on applying the lean manufacturing tool, Kanban, Awasare et al. (2017) observed a 26.5% production rate improvement after employing the tool.

7.3.2.7 Specification of Customer Value

The lean principle of customer value specification aims to direct manufacturing operations to produce quality and defect-free products according to customer specifications. For AD Sugar Factory, sugar colour, moisture, grain and packaging size, were fundamental specifications for their customers. Any deviation on any one of these resulted in non-conformance being raised against the organisation by the clients. These non-conformances would lead to product returns and subsequent loss of business, which is undesirable for the organisation. AD Sugar Factory employed the lean manufacturing tool customer involvement to ensure product production within acceptable customer specifications.Once product specifications were agreed upon through customer involvement, the firm subscribed to world-recognised management systems such as ISO, NOSA and FSCC, with internal and external audits to ensure compliance. As a result of the customer involvement strategy, product returns due to out-of-specification reasons were reduced by 30% during the period of the model implementation.

7.3.3 Stage 3 - Monitoring, Standardisation and Reward

Monitoring and evaluation of the lean framework implementation were specified in stage three. However, these critical reviews were carried out every month. Should there have been any unexpected variances in the results, these were quantified and a correction mechanism was immediately instituted at that stage of the framework implementation. Standardisation was carried out along the lean framework implementation, as presented in stage two above. Individuals, teams and sections were acknowledged and recognised in the monthly AD Sugar Factory magazine to sustain motivation. Pictures of winning individuals and groups were posted with a short acknowledgement note. In addition, shirts inscribed with lean principles and tools were awarded to individuals with the highest compliance percentages during the internal and external audits.

7.4 Effect of Implementing Lean Framework on AD Factory Performances (Gap Analysis)

As evidenced by the benefits and performance improvement realised during each implementation stage, the framework improved overall efficiency measures for AD Sugar Factory. After implementing the lean action plan to meet the mapped key performance indicators (KPIs), AD Sugar Factory evaluated the successes and overall impact of interventions recorded, and then a comparison was made to the before implementation performance. Before and after, the performance matrix was tabulated and compared, as shown in Table 7-8.

Table 7-8: Before and After Framework Implementation Performance Gap Analysis

KPI	AD Before	AD After	Benchmark	Established Gap*	Improvement**
Burn to Crush (BTC)	67.2 hours	57.6 hours	≤12 hours	- 45.6 hours	+9.6 hours
Pol % Cane (CQ)	13.60%	13.40%	≥15.35%	-1.95%	-0.20%
Preparation Index (PI)	91.20%	91.20%	≥92.00%	-0.80%	0.0%
Extraction	96.10%	96.90%	≥98.17%	-1.27%	+0.8%
Pol % Bagasse (BL)	1.70%	1.40%	≤0.60%	-0.80%	+0.3%
Pol % Filter Cake (FCL)	10.20%	10.20%	≤0.05%	-10.15%	
Boiler House recovery (BHR)	84.30%	88.10%	≥91.16%	-3.06%	+3.8%
Final Molasses Loss (FML)	4.60%	10.00%	≤7.13%	-2.87%	-5.40%
Undetermined Losses (UL)	4.50%	1.40%	≤0.10%	-1.30%	+3.2%
Overall Recovery (OR)	81.10%	85.40%	≥88.18%	-2.78%	+4.3%
Overall Time Efficiency (OTE)	83.10%	90.40%	≥98.79%	-8.39%	+7.3%
Cane to Sugar (CTS)	9.00	8.7	≤7.58	-1.12%	+0.3%

** - sign mean AD’s actual is worse than benchmark and + sign mean AD’s actual is above benchmark.*

*** - sign the AD’s measure worsened than before and + sign mean AD’s measure improved from before.*

Table 7-8 shows the gap analysis between AD’s actual key performance indicators after implementing the lean framework and the benchmarks established before implementation. It was observed that there were significant improvements in most of the AD Sugar Factory performance indicators, where 8 out of 10 minor performance indicators registered a positive change towards the industrial benchmarked targets. AD Sugar Factory realised a drop in product losses through undetermined and effluent losses of 212% and 13.8%, respectively. The reduction in losses contributes immensely to the CTS processing efficiency as measured by the overall recovery key performance indicator. The overall recovery improved to 85.4%, a 5% increase from the recovery achieved before implementing the lean manufacturing model. After implementing the framework, the product losses through bagasse reduced significantly by 23% over a 32-week AD Sugar Factory operating campaign. The main efficiency measures, namely OTE and CTS, improved by 7.3% and 0.3%, respectively. As a result of higher equipment availability, the overall energy employed per ton of cane processed dropped by 4.5%, thus reducing the overall cost per unit of the produced sugar. Overall, the implementation of the lean framework had a positive impact on the efficiency of the AD sugar factory.

7.5 Participants' Perceptions of the effect of the Lean Implementation Framework on AD Factory

The impact of implementing the lean framework at the AD factory was measured by a questionnaire survey (Appendix V). The Cronbach alpha for the instrument was 0.53, indicating acceptable, according to the reliability guide (Table 4-6). Table 7-9shows the survey's descriptive statistics on employee perceptions of the impact of the newly developed framework on AD operations.

Table 7-9: Effect of Lean Implementation Framework on AD Manufacturing Performances

Descriptive Statistics

		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
N	Valid	56	56	56	56	56	56	56	56	56	56	56	56	56
	Missing	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean		4.61	4.41	4.20	2.32	4.21	4.07	4.27	4.25	4.21	4.38	4.23	4.41	4.16
Median		5.00	4.00	4.00	2.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Mode		5	4	4	2	4	4	4	4	4	4	4	4	4
Std. Deviation		.623	.532	.553	1.162	.530	.684	.587	.611	.680	.590	.467	.565	.417
Sum		258	247	235	130	236	228	239	238	236	245	237	247	233
Percentiles	25	4.00	4.00	4.00	1.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
	50	5.00	4.00	4.00	2.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
	75	5.00	5.00	5.00	3.00	5.00	4.75	5.00	5.00	5.00	5.00	4.75	5.00	4.00

A fifty-six per cent response rate was obtained on the survey, and the rate was considered acceptable. There was a general high agreement among the survey participants, that introducing the lean implementation framework has improved AD manufacturing operations performance. All the constructs except reward, scored a mean above 4, indicating a high consensus regarding the positive effect that the framework had on improving efficiency and productivity. The results show a high score on employees' perception that the improved production performance and efficiency at AD Sugar Factory is as a result of the iemploying the developed Lean implementation framework for the sugar industry. The survey results indicated that employees perceived that all the action items implemented, namely, total productive maintenance, customer engagement, root cause analysis, performance audits and training on key performance indicators, had a bearing on AD Sugar Factory's performance. Overall, the AD Sugar Factory employees perceived that most of the interventions implemented through this framework were responsible for the improved productivity.

7.6 Chapter Conclusion

The chapter detailed the framework evaluation findings, where AD Sugar Factory implemented the proposed lean framework over one milling season for 32 weeks. AD Sugar Factory began by laying the foundation by pursuing the pre-implementation framework guidelines. After that, the factory implemented the lean principles and tools to identify and remedy the inefficiencies. Lastly, the factory evaluated the impact of implementing the lean framework by comparing the gap analysis between the period before/after implementation versus the standard benchmarks. The case study revealed that the proposed lean framework is easy to implement and increases measures of efficiencies for the sugar industry. The next chapter concludes the thesis.

CHAPTER 8

CONCLUSION, CONTRIBUTIONS AND RECOMMENDATIONS

8.1 Overview

The study sought to identify efficiency measures, lean waste and critical success factors for lean implementation in the sugar industry. The study proceeded as follows: Chapter 1 provided the background of the study, Chapter 2 presented high level overview of raw sugar manufacturing processes, Chapter 3 reviewed the Literature, Chapter 4 presented the methodology adopted for the study, Chapter 5 discussed phase 1 results, Chapter 6 presented the developed framework, Chapter 7 discussed the results of the phase 2 part of this study. Having met the study objectives in the preceding chapters, this chapter concludes the research by presenting study conclusions, contributions, recommendations, limitations and areas for future research.

8.2 Study Conclusions

The study undertook to develop a step-by-step lean implementation framework adapted to the sector and country context to fill in the gap in the body of knowledge and provide a much-needed tool to the sugar manufacturing sector. Three critical questions were asked to develop the framework, whose answers would feed into the lean implementation framework. The first question was, what are the key efficiency measures for the industry? Secondly, what is the lean waste common in the Mozambican sugar manufacturers? The next was, what are the key success factors for lean framework implementation in the Mozambican sugar industry? Lastly, the impact of the developed framework on the Mozambican sugar industry needed to be evaluated. The answers to the four questions were then used to develop a suitable lean manufacturing framework for the Mozambican sugar industry.

The study established that efficiency and productivity need to improve to bring down the high operating costs for the sugar sector to best fit into the highly competitive operating environment. Consequently, a tool to identify gaps in sugar manufacturing efficiencies and productivity was considered, and a framework to improve efficiency in the industry was developed

It was evident from the study outcomes that the sugar industry has opportunities to improve its manufacturing efficiencies and productivity. There are several unique wastes identified in the sugar sector and a concerted effort is needed to eliminate these wastes. The nineteen wastes identified for the sugar industry can be clustered into eight lean wastes defined in theliterature. The elimination or reduction of the waste in the sugar sector would in turn improve its efficiency. With this understanding of the study outcomes, the following section summarises the key findings of the study, based on the objectives.

8.2.1 Objective 1: Efficiency measures in the Mozambican sugar Industry

The study established that the key parameters to measure efficiency and productivity in the sugar industry are the measure of OTE CTS. The OTE measures the mechanical efficiencies, while the CTS measures processing efficiencies. Two key parameters were deemed appropriate efficiency measures in the sugar manufacturing sector. If they establish the best-operating levels for their cane to sugar ratio (CTS), it would be the indicator that would ensure that they seek to increase the amount of sugar made from each tonne of sugar cane crushed. The lower the ratio, the better the processing efficiencies or minimised losses due to poor extraction or chemical, or physical sugar losses in the processing value chain. Secondly, the OTE wouldindicate the time lost due to equipment availability issues and efficiencies in delivering cane to the sugar factories. This time, efficiency indicator points to losses due to opportunity cost each time the factories stop operating due to equipment breakdowns, cane supply issues and processing-related stoppages. It was established, and conclusions were made, that the two named efficiency measures cover many other minor ones; therefore, they are more representative.

8.2.2 Objective 2: Lean Waste in the Mozambican sugar Industry

Nineteen unique wastes in the sugar industry were identified in the context of Mozambique. These wastes were then grouped or clustered into the nine lean waste categories. The waste clusters were further ranked in terms of severity in the Mozambican sugar industry.

The motion waste ranked top for the industry, indicating huge losses due to non-value-adding movements within the Mozambican sugar factories. The second severity ranking was inventory waste, which indicates high losses due to overstocking of inventories. This waste can be minimised, but can not be eliminated as this falls under the necessary non-value-adding activities. The main reason for this loss is the business's seasonality nature and large amounts of inventories of the factory's final products, which tends to magnify the inventory waste. Secondly, most of the equipment operating and raw materials used in the sugar factories in Mozambique are specialised and therefore, imported. This has led to the sugar factories stocking up much of their costly critical spares onsite. This has been manifested by extensive and expensive onsite reserves held at the factories. By the nature of their business, the sugar factories are located in rural areas and sometimes far away from local suppliers in the cities, this as well has caused high inventory wastes.

Talent waste came out as the third waste for the industry, mainly due to ill-equipped employees, lack of skills and low quality of graduates from the secondary and tertiary institutions.The fourth was the defects waste emanating from equipment breakdown, reprocessing and customer complaints. Transportation waste was number five, mainly due to the need to transport final stock inventory to onsite storage. This storage is meant to cover the 20 weeks of off-crop shutdown maintenance.

Waiting time waste is also a significant contributor to the bucket of wastes in the Mozambican sugar industry. The waste mainly emanates from prolonged rain and equipment breakdown-induced stoppages. Over-production and overprocessing wastes complete the bottom-ranked waste in theindustry.The overprocessing stems from higher than specified products such as raw sugar pol, colour, molasses purity and Brix, all leading to efficiency losses on a mill. Overproduction waste arises due to the need to stock up to cover market demands during off-crop shutdown maintenance.

8.2.3 Objective 3: Critical Success Factors For Lean Implementation

The study also found eight critical success factors (CSF) for implementing the lean framework in the sugar industry. These ensure the successful and effective implementation of the lean framework for the industry. The need to select a championing team and train them on the lean implementation concepts and the implementation framework was established. This team of employees was representative of the different job levels (grading) and sections within the factory. They formed the core implementation and monitoring team, ensuring adequate buy-in across all levels and departments. Communication is crucial to a successful lean implementation initiative. This communication aspect ensures that there is enough preparation and awareness for all employees before the deployment of the new framework. Communication helps to capture any concerns that stakeholders may raise regarding the implementation journey. Adherence to the prevailing legal framework was critical to achieving a successful lean implementation for the sector. This aspect covers the need to align the framework with the prevailing labour laws of the countries.

An example of legal compliance would be any multi-skilling; the multi-functioning team would need to be treated and remunerated according to the law. The findings of the study indicated that auditing the current state of affairs at the factory is necessary to implement the framework effectively. The participants noted that auditing may take the forms of peer reviews or engaging consulting companies, must be clear and transparent, with results shared with all employees. This step would help with buy-in, alignment, and system requirements awareness. What was apparent from the results was the need to recognise and reward high-performing individuals and teams. The recognition may take the form of regular publishing of high performers in company communication forums or gifts such as mugs, lean branded shirts or financial rewards. Deliberate measures aimed at culture change are needed to successfully deploy the lean implementation framework, the new culture aligned to achieving high efficiencies through waste elimination need to be realised within the total workforce at all levels to see an effective framework deployment. A support system is needed to sustain the initiatives brought by the lean implementation, and these may include a budgeting system and information technology infrastructure for the implementation journey. Lastly, provision for feedback and control looping within the organisation must be available and functioning. The factor ensures that the necessary feedback from management and employees is shared timeously, and adjustments are effected without delay. The feedback may be achieved through regular inter-team review meetings for the lean implementation journey.

8.2.4 Objective 4: Lean Implementation Framework for the Mozambican Sugar Factories

After establishing the dominant waste and critical success factors for lean implementation, this section presents a lean manufacturing implementation model incorporating the efficiency measures, lean waste and critical success factors. The study established that the suitable framework for the sugar factories is a three-stage framework and context-specific. According to Sarkis and Talluri (2002), a framework must include an organisational strategic plan, current state, future state analysis, selection of alternatives, action plan, evaluation and feedback. The authors further noted that a framework should be able to evaluate essential factors quantitatively and qualitatively, both tangible and intangible. After identifying efficiency measures, wastes, and CSFs, the Lean implementation for the sugar industry was developed. A three-stage framework was created, with the first stage being preparation, the second stage being execution, and the third stage being standardisation, monitoring and reward. Each stage has its specific details guiding the user on what needs to be done.

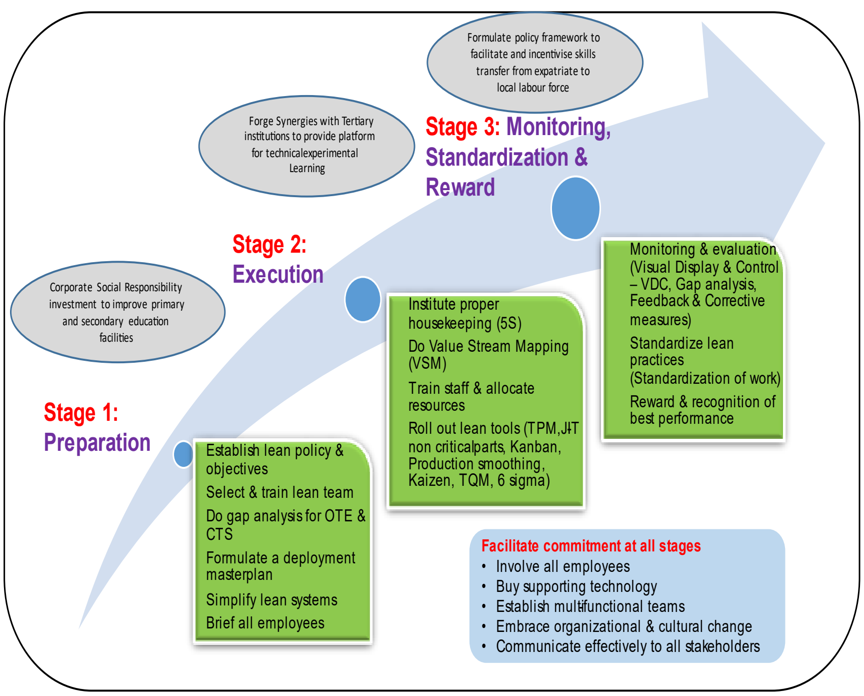

Figure 8-1: Lean Framework

The three-stage framework in Figure 8-1 was proposed in Chapter 6 and tested on AD Factory to validate its effectiveness, no adjustment was needed. It was found that the framework effectively improved the manufacturing efficiency of a chosen AD Sugar Factory. Quantitative performance gap analysis and employee measure of perception also confirmed that the improvements recorded in the case unit resulted from implementing the developed framework. This tested framework now represents the out of the study after integrating qualitative and quantitative results of the exploratory sequential study design employed in the study. Therefore, the study met all its objectives and provided a lean implementation framework suitable for the unique sugar industry.

The developed framework was evaluated and concluded that it addresses the central issue of efficiency improvement in the sugar industry. The framework was easy to understand and deploy in a real manufacturing setting. This framework is available to industry captains with no or minor adjustments to suit the specific context of the different organisations.

The validation results of the lean implementation framework showed improvement on overall time efficiency and cane to sugar ratio efficiency measures of the sugar industry in Mozambique. It is reasonable to conclude that the developed implementation framework suits Mozambique's industry contexts and significantly improves the sugar sector efficiencies and productivity. The industry captains can adopt it to turn around their manufacturing operations. Also, the policymakers in Mozambique will find this study useful to enact enabling supportive economic policies and provide policies that support the sugar industry’s performance. Lastly, The study thus serves as a launch pad for the academia to explore further some research areas covered in this study

Adopting the framework by the sugar industry leads to overall cost reductions and improved profitability through enhanced manufacturing efficiencies. Once the sugar sector achieves cost reductions through efficiency improvements, it will be competitive in the global market. This leads to the survival of the vital sugar industry in the developing and least developed countries such as Mozambique and the African continent as a whole, where the context is not very different to that of Mozambique. Hence, the socio-well-being of the citizens in these countries would be maintained and improved, resulting in subsequent economic and political benefits for the nations.

8.3 Summary of Contributions

The study contributes on three levels, industry (managers), policy makers (government) and the academia.

For the Industry

The outcomes of this study provided the two main efficiency measures for the Mozambican sugar industry: The CTS and OTEof the sugar manufacturing operations. The study outcome means that factories in Mozambique need to measure the two leading indicators to keep track of manufacturing efficiencies. These must then form the framework output or the targets on which performance is measured and tracked. Two indicators covering the whole manufacturing firm's performance will help managers focus and spend efforts on the main drivers of sugar industry efficiencies and productivity. It is recommended that all individual or team goal setting for the Mozambican sugar industry be linked to these two main efficiency measures. The sector is currently focusing on a wide range of key performance indicators, which results in managers directing and focusing essential financial and human resources on many aspects of the operations. As a result, the two main factors determining the overall efficiency and productivity of the sugar industry in Mozambique are not closely monitored as they should.

The waste in the Mozambican sugar sector was identified and ranked in order of per cent contribution to the overall waste basket. With these wastes identified, it will be more straightforward for managers to decide on appropriate lean tools from a pool of many, thereby avoiding trial and error when it comes to waste elimination efforts. Identifying waste and targeting the reduction of the same will enhance productivity and efficiency improvement in the Mozambican sugar industry. By using the outcomes from this study, managers and industry captains can develop research-based KPIs targeting the identified prevalent waste found and unique in the Mozambican industry. It is recommended that performance appraisals for individuals and teams be linked to the KPIs targeting reducing the identified top five waste in the industry. It is also imperative that the industry takes note of the top five wastes to shape their operational strategies, such as on-the-job training and skilling programmes, among many others. For mitigation against skills shortages, it is recommended that sugar companies work closely with the tertiary and vocational institutions in the country to enable them to produce graduates ready for the sugar industry. In an industry with such unique complexity and skill demands as the sugar industry, providing experimental learning to students in the science, technology and engineering faculties would provide the industry with competent graduates to feed its skilled labour demands.

The industry is advised to invest in renewable energy systems such as solar-powered mobile equipment and migrate from the currently predominant diesel and petrol-powered equipment to reduce transport waste. Outcome three from the study established the critical success factors for implementing performance and efficiency improvement systems in the context of the Mozambican sugar industry. The factors found were: 1) training, 2) Communication, 3) Legal Compliance, 4) Transparency, 5) Reward, 6) Culture change, and 7) support systems. These success factors should be addressed and considered for the lean implementation framework to succeed. Therefore, establishing the critical success factors helps managers to focus their resources on initiatives with a high chance of achieving results.

A lean implementation framework was then developed consisting of a three-stage approach, namely, 1) Preparation, 2) Execution, and 3) Monitor, Standardise & Reward. The three stages took the efficiency measures, lean waste, and the critical success factors into consideration, making the framework holistic and set to improve the performance of the sugar industry when adopted. The framework is the main outcome of this study and is the main tool required by managers to address efficiencies in the Mozambican sugar industry. Despite a plethora of literature on lean manufacturing, the industry has been yearning for a tool to guide industry captains in implementing this critical manufacturing strategy. The framework is unique and provides pointers to a logical sequence in which the lean manufacturing strategy can be deployed to get the most out of the sector's efficiencies. For the first time, the framework is tailor-made for sugar industry in Mozambique, for its best fit.

For the Policymakers

Policymakers, including the government, have a basis for formulating policies to enhance the efficiency of Mozambique's critical sugar industry. The government's policy on skills and development can be reviewed and improved to close the gap in skills and multiskilling found in the study. This study's findings may also facilitate changes to national high school, technical school and university curriculum policies in response to challenges faced by Mozambique's second-largest employer. The government could use the framework to identify areas where improvement in policy frameworks is required, for instance, incentivising synergies between the private sector and government regarding skilling and education systems. Some government can include tax incentives, skilling and training programmes funding. The key issue identified as low literacy levels and shortage of skills need concerted public and private partnerships. Therefore, it is recommended that the sugar manufacturers forge synergies with the local and government institutions of learning to address the low literacy levels in the communities in which they operate. The low literacy levels equally impact manufacturers, so they should start by investing in primary and secondary education facilities. Some of the ways suggested among many options were subsidising the cost of education, building new schools, upgrading school infrastructure and providing scholarships. A related finding was made by Birdsall et al. (2005), who state that inadequate education and high rates of dropouts in Africa, particularly in sub-Saharan Africa, are also a problem, with only 51% of the population completing primary and secondary education.

For the academia

Academics can draw further research from the proposed lean implementation framework for improving efficiencies and productivity in the critical sector of the Mozambican sugar industry. The framework for implementing lean is relevant to establishing a logical step-by-step road map to eliminate the waste in the Mozambican sugar industry, thereby improving efficiency, productivity and competitiveness. The study adds to the body of knowledge on three main dimensions: establishing efficiency measures for the Mozambican sugar industry, examining and ranking the lean waste for the industry, and providing a list of lean implementation success factors and the framework. Each of these dimensions of the sugar sector is missing in the body of literature. Therefore, this study goes a long way to fill in the gap in the body of knowledge.

8.4 Limitations of Study

This study had its limitations. and Creswell and Creswell (2005) defined limitations as factors that the study cannot control. The limitations are the exceptions, reservations, qualifications, problems, and weaknesses related to the study (Neuman, 2003). The time frame allotted for the research is relatively short to enable an extensive examination of the vast operations information. However, the study used acclaimed research tools to collect credible data for analysis on time to mitigate.

The research was predominately conducted in the sugar industry, limiting the study findings or outcomes to only one sector. Also, some respondents may not thoroughly comprehend the intent of the questions and provide inaccurate responses. The study, however, endeavoured to simplify probing questions.

While the exploratory sequential mixed methods research methodology adopted for this study helped to achieve the intended objectives, it does notexplain the extent to which the waste and critical success factors impact efficiency measures for the Mozambicansugar sector, as it fell outside the scope of the study. Establishing causal and coefficients of correlations helps managers to form a solid basis for resource allocation targeting the high-impact factors.

Mozambique uses Portuguese as the official language, while the research was conducted in English. The danger was a misunderstanding between the study and the participants. The majority of the participants for the study were purposively selected, and most are conversant with both languages. This mitigated the potential language barrier problems. Where required, an interpreter was used to ensure effective communication and left no chance of miscommunication.

Lastly, the study may not have considered other variables that could influence the performance improvements or a lack thereof. For this research, these other factors have been deemed uniform and *ceteris paribus*.

8.5 Suggestions for Future Research

A single company was used to validate the framework, and according to Krusenvik (2016), it is not easy to generalise these findings across the whole sector with a single case study. Therefore, there is an opportunity to replicate the framework's application across all four sugar mills in Mozambique.

Secondly, it is possible to apply this framework in other sugar industries beyond the Mozambican borders. Therefore, it is an opportunity for future research to validate this framework in other developing nations with a thriving sugar industry.

Thirdly, the framework may be tried in other non-sugar-related industries to establish appropriateness since the country context would be similar. This will help improve performances and efficiencies across all Mozambique manufacturing sectors, ensuring this industry’s long-term survival.

Lastly, despite this study's comprehensive qualitative and quantitative analysis, further statistical analysis of the case study results is needed to establish correlations and causal relationships between the implemented framework and the efficiency measures outcomes. It will determine how each step and construct impact the manufacturing sector's performance improvements, channelling resources to the areas with the highest returns in terms of efficiency and productivity improvements.

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APPENDIX I – REGIONAL MILLS 2017 TO 2020 PERFORMANCE INDICATORS

Year	SYMBOLS OF FACTORIES	OTE	P%C	Ext	BHR	OR	CTS	P%B	P%FC	FML	UL
2020	MH-AVE	82.66	14.32	96.32	88.85	85.58	8.18	3.68	0.12	8.96	1.66
	UB-AVE	84.36	13.52	95.74	85.93	82.27	8.95	4.26	-	10.42	3.04
	SM	84.54	14.04	96.29	91.16	87.78	8.06	3.71	0.35	8.06	0.10
	NH *	88.65	14.05	95.93	83.76	80.35	8.79	4.07	0.62	11.10	3.86
	DW *	88.18	14.30	96.71	87.80	84.91	8.20	3.29	0.06	9.52	2.22
	HV-AVE	77.98	14.13	96.84	90.40	87.54	8.03	3.16	-	7.66	1.64
	TR-AVE	72.79	14.60	97.16	86.07	83.62	8.15	2.84	0.26	8.33	4.95
	NK-AVE	80.06	14.16	94.01	85.99	80.83	8.69	5.99	0.56	9.66	2.95
	MW *	68.56	12.10	95.35	83.58	79.69	10.30	4.65	0.42	9.88	5.36
	RU *	84.67	11.65	93.84	85.28	80.03	10.64	6.16	0.99	10.57	2.25
	MA *	75.23	12.84	95.38	80.41	76.70	10.09	4.62	0.64	11.39	6.65
	MB *	63.62	11.94	94.50	80.83	76.39	10.86	5.50	0.76	12.84	4.52
	XN *	83.55	13.59	96.15	84.30	81.05	9.01	3.85	-	10.32	4.78
	GH-AVE	78.99	13.44	96.26	83.28	80.16	9.21	3.74	0.38	10.99	4.58
	NB	79.05	13.40	96.41	79.50	76.65	9.56	3.59	1.85	12.45	5.37
	UC *	85.21	13.88	96.15	85.45	82.14	8.66	3.85	-	9.76	4.26
	ES *	87.13	13.40	96.90	84.51	81.88	8.99	3.10	0.14	11.58	3.27
	SZ-AVE	87.32	13.50	96.97	83.60	81.06	9.03	3.03	0.17	12.35	3.39
	UK *	75.68	14.74	97.51	85.25	83.12	8.07	2.49	-	11.61	2.77
	ML *	88.06	14.57	96.89	84.45	81.82	8.31	3.11	-	11.80	3.23
	KM-AVE	86.00	14.27	97.07	88.57	85.98	8.03	2.93	-	9.04	2.05
	PG *	85.01	13.71	96.56	86.77	83.79	8.57	3.44	-	10.76	1.98
	UF *	81.78	13.78	95.93	88.61	85.00	8.40	4.07	0.32	7.95	2.65
	FX-AVE	66.09	14.13	98.01	87.26	85.52	8.17	1.99	-	9.58	2.92
	AK *	71.74	13.95	96.49	84.94	81.95	8.65	3.51	-	10.16	4.24
	DL	68.53	13.81	96.37	85.79	82.68	8.64	3.63	0.92	7.81	4.96
	MS-AVE	69.59	13.50	97.60	83.76	81.75	8.96	2.40	-	12.40	3.45
2019	MH-AVE	72.34	14.68	95.97	89.63	86.02	8.05	4.03	0.09	7.20	2.66
	UB-AVE	85.23	13.42	95.62	86.93	83.13	8.92	4.38	-	9.55	2.92
	SM	82.07	14.30	96.03	90.85	87.24	7.97	3.97	0.93	7.13	0.74
	NH *	84.86	13.66	94.53	83.45	78.89	9.22	5.47	0.30	10.82	4.53

Year	SYMBOLS OF FACTORIES	OTE	P%C	Ext	BHR	OR	CTS	P%B	P%FC	FML	UL
	DW *	86.22	14.61	96.78	87.73	84.91	8.02	3.22	0.05	9.00	2.82
	HV-AVE	94.30	14.59	96.49	90.48	87.31	7.80	3.51	-	7.71	1.47
	TR-AVE	98.79	14.55	97.60	87.27	85.17	8.03	2.40	0.26	7.64	4.52
	NK-AVE	86.11	14.64	94.44	87.76	82.88	8.19	5.56	0.76	8.77	2.04
	MW *	84.55	12.75	95.67	86.28	82.54	9.43	4.33	0.34	9.76	3.02
	RU *	88.14	12.58	94.31	86.34	81.43	9.69	5.69	0.60	10.18	2.10
	MA *	80.53	13.62	95.62	85.52	81.78	8.93	4.38	0.55	8.88	4.42
	MB *	71.64	13.25	96.50	86.70	83.66	8.94	3.50	0.39	9.79	2.65
	XN *	88.48	13.47	96.66	87.50	84.58	8.70	3.34	-	9.99	2.09
	GH-AVE	82.00	13.03	96.25	83.45	80.32	9.48	3.75	0.63	11.74	3.54
	NB	81.55	13.40	96.61	81.33	78.57	9.40	3.39	1.57	12.39	4.00
	UC *	87.48	13.99	96.05	87.19	83.74	8.46	3.95	-	8.26	4.04
	ES *	86.07	13.60	96.50	84.64	81.68	8.89	3.50	0.15	10.32	4.30
	SZ-AVE	87.15	13.83	97.28	86.15	83.81	8.53	2.72	0.15	11.36	1.96
	UK *	72.21	14.56	97.58	87.23	85.12	8.01	2.42	-	10.68	1.78
	ML *	90.77	15.04	97.26	85.03	82.70	7.96	2.74	-	11.24	3.84
	KM-AVE	84.84	14.72	97.71	88.25	86.22	7.77	2.30	-	8.27	3.21
	PG *	80.01	13.37	96.52	82.34	79.47	9.28	3.48	-	11.82	5.18
	UF *	78.67	13.18	96.08	86.59	83.20	8.98	3.92	0.35	9.68	2.85
	FX-AVE	84.45	13.39	98.10	86.71	85.07	8.68	1.90	-	10.94	2.10
	AK *	67.44	13.44	96.33	86.66	83.48	8.83	3.67	-	9.83	3.12
	DL	71.66	13.3	95.16	87.38	83.16	8.92	4.84	0.98	8.32	2.69
	MS-AVE	77.21	13.61	97.05	86.55	84.00	8.68	2.95	-	10.50	2.56
2018	MH-AVE	77.08	14.54	96.24	89.11	85.76	8.44	3.76	0.11	7.77	2.60
	UB-AVE	87.49	13.53	96.57	86.67	83.70	8.80	3.43	-	10.61	2.26
	SM	83.07	14.16	96.43	90.57	87.34	8.04	3.57	0.46	7.54	1.09
	NH *	82.95	13.96	94.56	81.93	77.48	9.18	5.44	0.15	11.66	5.28
	DW *	86.20	14.45	96.99	88.38	85.72	8.03	3.01	0.05	9.27	1.95
	HV-AVE	77.47	14.43	97.06	90.85	88.18	7.81	2.94	-	7.46	1.42
	TR-AVE	73.21	14.51	97.33	87.60	85.26	8.08	2.67	0.26	7.92	3.89
	NK-AVE	88.71	14.36	95.36	88.14	84.05	8.24	4.64	0.42	8.45	2.44
	MW *	74.68	12.24	94.98	85.91	81.60	9.94	5.02	0.31	9.02	4.05
	RU *	85.48	12.03	94.32	85.66	80.79	10.23	5.68	0.63	10.08	2.80
	MA *	75.78	13.18	96.15	85.99	82.67	9.12	3.85	0.52	9.24	3.71

Year	SYMBOLS OF FACTORIES	OTE	P%C	Ext	BHR	OR	CTS	P%B	P%FC	FML	UL
	MB *	68.65	13.45	96.75	87.31	84.47	8.73	3.25	0.25	9.37	2.65
	XN *	84.11	13.40	97.44	89.91	87.61	8.45	2.56	-	8.35	1.47
	GH-AVE	82.37	12.98	96.75	82.96	80.25	9.52	3.25	0.44	11.78	4.28
	NB	79.71	13.92	96.57	82.37	79.54	8.94	3.43	2.22	12.10	2.69
	UC *	87.09	14.05	96.83	88.86	86.04	8.19	3.17	0.09	8.89	1.81
	ES *	83.75	13.95	97.07	85.85	83.33	8.51	2.93	0.14	9.57	3.98
	SZ-AVE	84.57	12.76	97.12	86.18	83.69	9.25	2.88	0.16	11.41	1.85
	UK *	68.84	13.95	97.28	85.37	83.05	8.58	2.72	-	12.26	1.98
	ML *	87.85	15.35	97.35	84.06	81.83	7.90	2.65	-	10.72	4.77
	KM-AVE	85.74	14.87	97.82	88.45	86.52	7.63	2.18	-	9.16	2.13
	PG *	83.59	14.26	96.54	84.87	81.92	8.46	3.46	-	10.96	3.66
	UF *	76.88	13.19	96.85	86.80	84.07	8.89	3.15	0.23	10.04	2.50
	FX-AVE	71.15	13.17	98.17	84.63	83.09	9.04	1.83	-	12.04	3.05
	AK *	68.23	13.21	96.91	85.90	83.24	9.01	3.09	-	10.80	2.86
	DL	64.59	13.29	95.91	86.39	82.87	8.96	4.09	1.76	8.41	2.88
	MS-AVE	72.33	13.29	97.13	83.48	81.09	9.20	2.87	-	11.62	4.42
2017	ML *	87.47	14.93	96.76	83.99	81.27	8.16	3.24	-	12.82	2.58
	KM-AVE	85.81	14.45	97.23	87.73	85.30	7.97	2.77	-	9.71	2.22
	PG *	77.52	13.98	95.64	84.13	80.46	8.79	4.36	-	11.25	3.93
	UF *	73.71	11.81	94.13	81.74	76.94	10.83	5.87	0.40	11.94	4.84
	FX-AVE	70.01	11.77	97.99	80.04	78.43	10.67	2.01	-	14.62	4.93
	AK *	56.68	11.62	96.80	70.53	68.27	12.44	3.20	-	14.80	13.57
	DL	63.86	11.94	95.69	83.25	79.67	10.38	4.31	1.43	10.02	4.57
	MS-AVE	73.53	12.39	97.73	84.17	82.29	9.71	2.27	-	11.83	3.61
	GH-AVE	76.38	12.11	96.67	83.44	80.66	10.16	3.33	0.45	12.33	3.24
	NB	80.57	12.93	96.43	78.87	76.06	10.06	3.57	2.21	13.15	4.99
	UC *	81.22	13.02	96.21	87.29	83.99	9.04	3.79	0.24	10.07	1.91
	ES *	81.11	12.38	96.61	85.12	82.24	9.69	3.39	0.14	10.84	3.35
	SZ-AVE	88.44	12.51	97.34	86.38	84.08	9.40	2.66	0.17	11.50	1.58
	UK *	63.1	11.83	96.88	78.96	76.5	10.97	3.12	-	16.78	3.6
	MH-AVE	77.61	14.42	96.05	88.38	84.89	8.35	3.95	0.08	8.62	2.47
	UB-AVE	84.30	13.42	96.20	85.46	82.22	9.03	3.80	-	10.69	3.28
	SM	77.64	14.25	95.88	89.07	85.39	8.17	4.12	0.60	8.93	0.96
	NH *	84.39	13.65	94.60	83.00	78.52	9.28	5.40	0.18	11.91	4.00

Year	SYMBOLS OF FACTORIES	OTE	P%C	Ext	BHR	OR	CTS	P%B	P%FC	FML	UL
	DW *	88.45	14.43	97.23	88.52	86.07	8.00	2.77	0.05	9.08	2.04
	HV-AVE	81.47	15.02	96.96	89.91	87.18	7.58	3.04	-	7.71	2.08
	TR-AVE	79.33	15.04	97.31	85.83	83.52	7.82	2.69	0.31	7.77	5.71
	NK-AVE	88.30	14.40	95.61	86.77	82.96	8.32	4.39	0.32	9.44	2.88
	MW *	89.19	13.44	94.56	88.81	83.98	8.78	5.44	0.26	8.65	1.67
	RU *	90.70	13.61	94.87	87.63	83.13	8.78	5.13	0.46	9.53	1.75
	MA *	61.09	13.08	95.95	83.96	80.56	9.41	4.05	0.53	9.53	5.33
	MB *	79.95	13.15	96.41	83.08	80.10	9.42	3.59	0.36	12.16	3.78
	XN *	85.53	13.30	97.33	87.26	84.93	8.78	2.67	-	9.38	3.03
	Min	56.68	11.62	93.84	70.53	68.27	7.58	1.83	0.05	7.13	0.10
	Max	98.79	15.35	98.17	91.16	88.18	12.44	6.16	2.22	16.78	13.57

Key performance indicators - key

OTE	Overall Time Efficiency
P%C	Pol % cane
Ext	Extraction
BHR	Boiling house recovery
OR	Overall recovery
CTS	Cane to Sugar
P%B	Pol% Bagasse
P%FC	Pol % Filter Cake
FML	Final Molasses Losses
UL	Undetermined Losses

APPENDIX II - LEVEL OF ALIGNMENT QUESTIONNAIRE

	1	2	3	4
Before training and awareness interventions	**Strongly disagree**	**Disagree**	**Agree**	**Strongly agree**
Q1: I know the organisation competitors				
Q2: I know the organisation market share				
Q3: I know organisation strategy and vision				
Q4: I know the organisation KPI (Performance Indicators)				
Q5: I know the organisation productivity measurements				
Q6: I have been trained in the efficiency and productivity instruments				
Q7: There is a need to improve organisation performance				
Q8: My supervisor and I discuss and agree on organisation performances				
After training and awareness interventions	**Strongly disagree**	**Disagree**	**Agree**	**Strongly agree**
Q1: I know the organisation competitors				
Q2: I know the organisation market share				
Q3: I know organisation strategy and vision				
Q4: I know the organisation KPI (Performance Indicators)				
Q5: I know the organisation productivity measurements				
Q6: I have been trained in the efficiency and productivity instruments				
Q7: There is a need to improve organisation performance				
Q8: My supervisor and I discuss and agree on organisation performances				

APPENDIX III - ALIGNMENT QUESTIONNAIRE RESPONSES

Participant Identifier	Before Training										After Training								
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Total		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Total
Participant 1	2	3	3	3	4	3	3	3	**24**		3	4	3	4	3	3	4	4	**28**
Participant 2	1	1	2	2	3	4	np	2	**15**		3	2	3	2	3	4	4	3	**24**
Participant 3	2	3	2	3	2	3	2	3	**20**		2	3	2	3	2	4	3	2	**21**
Participant 4	1	2	3	2	3	4	3	1	**19**		2	3	2	3	2	4	2	3	**21**
Participant 5	1	2	3	2	3	2	4	2	**19**		3	4	2	3	4	2	3	2	**23**
Participant 6	1	2	1	2	1	4	3	2	**16**		3	2	4	2	4	2	3	2	**22**
Participant 7	1	2	3	2	3	1	2	3	**17**		2	4	3	2	3	2	3	1	**20**
Participant 8	1	2	3	2	2	3	2	3	**18**		2	3	4	3	2	3	2	3	**22**
Participant 9	1	2	3	2	3	4	3	1	**19**		2	3	2	3	4	4	2	2	**22**
Participant 10	2	3	4	2	2	3	2	3	**21**		2	3	2	3	2	4	2	1	**19**
Participant 11	2	2	2	2	3	2	3	1	**17**		3	3	3	2	3	2	3	1	**20**
Participant 12	1	2	2	3	2	3	2	np	**15**		2	2	2	4	2	3	4	2	**21**
Participant 13	1	2	3	2	3	4	2	3	**20**		2	1	3	2	3	2	4	2	**19**
Participant 14	2	4	3	2	3	3	2	3	**22**		3	2	4	2	2	3	2	4	**22**
Participant 15	1	2	2	3	4	2	4	2	**20**		3	3	3	4	3	4	3	2	**25**
Participant 16	4	2	3	4	2	4	2	4	**25**		3	4	3	2	4	2	3	1	**22**
Participant 17	2	3	4	2	3	2	3	2	**21**		2	3	4	1	3	2	4	2	**21**
Participant 18	1	2	4	2	1	2	3	1	**16**		4	3	1	2		1	3	2	**16**
Participant 19	1	2	3	2	3	4	3	3	**21**		1	2	3	3	2	3	4	3	**21**
Participant 20	4	2	3	3	3	1	3	3	**22**		4	4	4	4	4	3	4	4	**31**
Participant 21	3	1	2	3	3	4	4	3	**23**		4	1	4	4	3	3	4	3	**26**
Participant 22	4	4	4	3	4	3	4	3	**29**		4	4	4	4	4	3	4	3	**30**
Participant 23	2	2	1	3	2	2	4	2	**18**		2	2	3	3	3	2	4	3	**22**
Participant 24	3	2	3	3	3	3	4	3	**24**		3	3	4	3	3	4	4	4	**28**
Participant 25	3	3	3	3	3	2	4	3	**24**		3	3	3	3	3	2	4	3	**24**
Participant 26	3	2	3	1	3	1	4	3	**20**		3	2	3	1	3	2	4	3	**21**
Participant 27	3	3	2	3	3	2	4	3	**23**		3	3	3	3	3	2	4	3	**24**
Participant 28	2	2	1	2	2	1	4	2	**16**		3	3	4	2	2	1	4	2	**21**
Participant 29	2	2	2	3	3	2	4	3	**21**		3	3	3	4	3	2	4	3	**25**
Participant 30	3	4	4	4	4	4	3	4	**30**		3	4	4	4	4	4	4	4	**31**
Participant 31	3	2	2	2	3	3	3	1	**19**		3	3	4	4	3	3	3	3	**26**
Participant 32	4	2	3	3	3	2	3	3	**23**		4	2	4	4	3	3	3	3	**26**

Participant Identifier	Before Training										After Training								
	Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Total**		**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Total**
Participant 33	3	2	3	3	3	2	3	3	**22**		3	2	3	3	3	2	3	3	**22**
Participant 34	4	2	3	4	3	2	3	3	**24**		4	2	4	4	3	2	3	3	**25**
Participant 35	3	1	2	1	3	3	4	4	**21**		3	2	4	3	3	3	4	4	**26**
Participant 36	4	3	2	3	3	3	4	3	**25**		4	3	4	3	3	3	3	3	**26**
Participant 37	3	3	1	3	3	2	3	2	**20**		4	4	4	3	3	3	4	4	**29**
Participant 38	3	2	1	2	2	4	4	3	**21**		3	4	3	4	3	4	4	4	**29**
Participant 39	4	3	3	3	4	2	3	4	**26**		4	3	3	4	4	2	3	4	**27**
Participant 40	3	3	3	3	3	3	4	3	**25**		3	3	3	3	3	3	4	3	**25**
Participant 41	4	2	1	3	2	2	4	3	**21**		4	4	4	3	3	3	4	3	**28**
Participant 42	3	2	2	2	3	3	4	3	**22**		3	2	3	3	3	3	4	4	**25**
Participant 43	3	2	2	1	1	1	2	1	**13**		3	3	3	3	3	3	3	3	**24**
Participant 44	3	1	1	2	2	4	4	3	**20**		3	3	3	3	3	4	4	4	**27**
Participant 45	2	2	2	2	2	2	2	2	**16**		3	2	3	2	3	3	3	3	**22**
Participant 46	3	1	1	2	2	4	4	3	**20**		3	3	3	3	3	4	4	4	**27**
Participant 47	3	3	2	3	3	1	4	3	**22**		3	3	4	3	3	2	4	3	**25**
Participant 48	2	1	2	2	2	2	4	3	**18**		3	2	3	2	2	2	4	3	**21**
Participant 49	2	1	2	2	2	2	4	3	**18**		3	2	3	2	2	2	4	3	**21**
Participant 50	1	3	4	1	3	4	4	4	**24**		1	3	4	3	4	4	4	4	**27**
Participant 51	2	2	1	2	2	2	3	2	**16**		3	2	3	3	4	4	4	3	**26**
Participant 52	2	2	1	2	1	2	2	2	**14**		2	2	4	3	1	3	4	3	**22**
Participant 53	2	1	2	2	3	2	3	4	**19**		3	2	3	3	2	2	4	3	**22**
Participant 54	1	2	2	2	2	2	4	3	**18**		2	3	3	2	2	2	4	4	**22**
Participant 55	2	1	2	2	2	2	3	3	**17**		3	2	3	2	3	3	4	3	**23**
Participant 56	1	2	2	2	1	2	2	2	**14**		3	2	3	3	3	4	3	3	**24**
Participant 57	1	2	2	2	2	2	3	3	**17**		1	2	3	2	3	2	4	3	**20**
Participant 58	2	2	2	2	3	2	4	3	**20**		3	3	3	3	4	3	4	3	**26**
Participant 59	2	1	1	2	2	2	2	3	**15**		3	2	3	3	3	3	4	3	**24**
Participant 60	2	1	2	2	3	2	4	3	**19**		2	2	3	2	3	3	4	3	**22**
Participant 61	2	1	1	2	2	2	4	3	**17**		3	2	3	3	3	3	4	3	**24**
Participant 62	1	2	2	2	3	2	4	2	**18**		3	2	3	3	3	3	4	4	**25**
Participant 63	2	2	2	2	3	2	4	3	**20**		2	2	3	3	3	4	4	3	**24**
Participant 64	2	2	3	2	2	3	4	3	**21**		2	3	3	3	4	3	4	3	**25**
Participant 65	2	2	2	2	3	4	4	3	**22**		3	2	3	4	3	4	4	3	**26**
Participant 66	2	2	2	2	2	2	4	3	**19**		2	3	3	3	3	3	4	3	**24**

Participant Identifier	Before Training										After Training								
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Total		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Total
Participant 67	2	2	2	3	2	3	4	3	**21**		3	3	4	3	4	3	4	3	**27**
Participant 68	2	2	2	2	3	3	4	4	**22**		2	2	4	4	4	3	4	4	**27**
Participant 69	2	2	2	2	3	2	4	3	**20**		2	2	3	2	4	3	4	3	**23**
Participant 70	1	2	1	2	3	2	4	3	**18**		2	2	4	3	4	3	4	4	**26**
Participant 71	2	1	2	2	2	3	4	3	**19**		3	2	4	3	4	3	4	4	**27**
Participant 72	3	2	3	4	4	3	3	4	**26**		3	2	3	4	4	3	3	4	**26**

np-not being provided

APPENDIX IV - WASTE IDENTIFICATION QUESTIONNAIRE

0 - zero waste; 1 - little Waste; 2 - Moderate Waste; 3 - High Waste; 4 -Excessive Waste								
Process Description	Talent Waste	Motion Waste	Transportation Waste	Inventory Waste	Waiting Waste	Overproduction Waste	Excess Processing	Defects
Truck Calling								
Truck Weighing								
Cane Loading								
Cane Preparation								
Juice Extraction								
Milling (dewatering)								
MJ Weighing, Storage, and pumping								
Clarification								
Mud Return								
Clear Juice Heating								
Evaporation								
Crystalisation								
Curing								
Raw Sugar Conveying								
Prepack ffs								
Bailer machine								
Packed product conveying								
Warehouse stacking and Storage								
Warehouse Dispatching								
Industrial Stores								

APPENDIX V - EFFECT OF LEAN IMPLEMENTATION QUESTIONNAIRE

	Effect of Lean implementation	Strongly disagree	Disagree	Don't Know	Agree	Strongly Agree
		1	2	3	4	5
1	5S helped improve production efficiency					
2	Sharing of KPI was helpful in productivity					
3	At station notice boards ensured information is shared to all levels					
4	Reward was linked to performance					
5	Multiskilling yielded better production efficiency					
6	Audit results Recognition in Xifane magazine made employees more productive					
7	Internal and external audits continually expose areas of improvement					
8	Computer based maintenance improved equipment availability					
9	Food safety training improved defects in production lines					
10	Constant customer engagement helped in customer supplier relationship					
11	Training on KPI improved employees' work output					
12	Daily meetings discussions on production performance helped improve on KPIs					
13	Root cause analysis and HARZOPs reduced equipment breakdowns					

APPENDIX VI - EFFECT OF LEAN IMPLEMENTATION RESPONSES

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
Participant 1	5	5	4	4	5	5	4	5	5	5	4	5	4
Participant 2	4	4	4	1	4	4	4	4	5	5	4	5	4
Participant 3	5	5	4	3	4	4	5	5	5	5	4	4	5
Participant 4	5	4	4	2	4	4	5	5	4	4	5	4	4
Participant 5	4	4	5	2	4	5	5	4	4	5	5	4	4
Participant 6	5	5	4	4	3	4	4	5	5	4	4	5	4
Participant 7	5	4	5	3	5	4	5	4	4	5	4	5	4
Participant 8	5	4	4	3	4	4	4	4	4	4	4	4	4
Participant 9	5	5	5	1	3	3	3	3	4	4	5	4	4
Participant 10	5	5	4	2	4	4	4	5	5	5	4	4	5
Participant 11	5	5	4	4	5	5	4	4	4	4	5	4	4
Participant 12	5	5	4	1		4	4	4	4	5	4	4	5
Participant 13	5	4	4	4	5		3	4	4	4	4	5	4
Participant 14	5	4	4	5	5	5	5	4	4	4	5	4	4
Participant 15	5	4	4	1	5	5	5	5	4	5	4	5	4
Participant 16	5	4	4	2	5	4	5	4	4	5	4	5	5
Participant 17	4	4	5	3	4	5	5	4	4	4	4	5	4
Participant 18	5	5	5	2	4	5	4	5	4	5	4	4	4
Participant 19	5	5	4	1	4	4	4	5	5	5	5	4	4
Participant 20	5	5	4	2	4	4	4	4	4	5	5	5	4
Participant 21	4	5	4	2	4	4	4	5	4	3	4	5	4
Participant 22	5	5	4	1	4	3	4	4	4	4	5	5	4
Participant 23	5	5	4	3	4	4	4	4	5	4	4	4	4
Participant 24	5	4	3	4	4	4	5	4	5	4	4	4	4
Participant 25	5	5	4	4	4	5	4	3	3	4	4	3	4
Participant 26	4	4	5	1	4	4	5	4	4	5	4	4	4
Participant 27	5	5	3	2	4	4	4	5	4	4	4	5	4
Participant 28	4	5	4	2	4	4	4	5	5	4	4	5	3
Participant 29	4	4	5	3	4	5	5	4	5	4	4	5	4
Participant 30	5	5	4	2	4	5	5	4	4	4	5	4	4
Participant 31	4	4	5	2	5	5	4	4	5	4	4	5	4
Participant 32	5	4	3	1	4	3	4	4	4	3	4	5	4
Participant 33	5	5	4	3	4	5	5	5	4	4	4	4	4
Participant 34	5	4	4	4	5	4	4	4	4	4	4	5	4
Participant 35	4	4	5	2	5	3	3	3	3	4	4	4	4
Participant 36	4	4	5	2	4	4	4	5	4	4	4	4	4
Participant 37	4	4	5	2	4	4	5	4	4	5	4	5	4

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
Participant 38	5	4	4	1	5	5	4	5	5	4	4	4	5
Participant 39	4	4	5	1	4	4	5	5	4	4	4	5	4
Participant 40	4	4	4	2	5	4	5	4	4	4	5	5	5
Participant 41	4	4	4	1	5	3	4	4	4	5	5	5	5
Participant 42	4	3	4	1	4	3	3	3	3	4	4	3	4
Participant 43	5	4	4	1	4	4	4	5	5	4	4	5	4
Participant 44	5	4	5	3	4	4	4	4	4	5	4	5	4
Participant 45	5	4	3	2	4	4	5	5	5	5	4	4	5
Participant 46	5	4	4	1	4	4	4	4	5	5	4	4	4
Participant 47	3	4	4	2	4	3	4	5	4	4	4	5	4
Participant 48	5	5	4	3	4	5	5	5	5	4	4	5	4
Participant 49	5	5	4	1	4	4	4	4	5	5	5	4	4
Participant 50	5	5	4	5	5	4	4	4	4	5	5	4	5
Participant 51	5	5	4	2	4	4	4	4	5	5	4	4	4

APPENDIX VII - INFORMED CONSENT LETTER

Informed Consent Letter 3C

UNIVERSITY OF KWAZULU-NATAL

GRADUATE SCHOOL OF BUSINESS AND LEADERSHIP

Dear Respondent,

DOCTOR OF BUSINESS ADMINISTRATION RESERCH PROJECT

Researcher: Blessward.N. Chinhoi (+258 850888758) Email: 218083307@stu.ukzn.ac.za

Supervisor: Prof Muhammad Hoque (+27 31 260 8696) Email: hoque@ukzn.ac.za

Research Office: Mariette Snyman Tel: +27 31 260 8350 Email: snymanm@ukzn.ac.za

I, **Blessward Chinhoi** a Doctoral Candidate, at the Graduate School of Business and Leadership, of the University of KwaZulu Natal. You are invited to participate in a research project entitled **Implementation of Lean manufacturing framework for Sugar industry in Mozambique**. The aim of this study is to: Apply Lean implementation theoretical framework to Identify, demonstrate and decrease those activities that do not add value to the Manufacturing process in Sugar Industry.

Through your participation I hope to understand how Lean manufacturing tools help identify the manufacturing wastes in sugar industry thereby improving productivity and efficiency. The results of the focus group are intended to contribute to business' adoption of Lean manufacturing philosophy as a methodology to enhance profitability and become competitive in the international sugar market.

Your participation in this project is voluntary. You may refuse to participate or withdraw from the project at any time with no negative consequence. There will be no monetary gain from participating in this survey/focus group. Confidentiality and anonymity of records identifying you as a participant will be maintained by the Graduate School of Business and Leadership, UKZN.

If you have any questions or concerns about completing the questionnaire or about participating in this study, you may contact me or my supervisor at the numbers listed above.

The survey should take you about **20** minutes to complete. I hope you will take the time to complete this survey.

Sincerely

Investigator's signature____________________________________ Date_________________

This page is to be retained by participant

APPENDIX VIII - LETTER OF CONSENT

UNIVERSITY OF KWAZULU-NATAL

GRADUATE SCHOOL OF BUSINESS AND LEADERSHIP

DOCTOR OF BUSINESS ADMINISTRATION RESERCH PROJECT

Researcher: Blessward Ngonidzashe Chinhoi (850888758)

Supervisor: Prof Muhammad Hoque (+27 31 260 8696)

Research Office: Ms. Zikhona Mojapelo 031-260 2784

CONSENT

I………………………………………………………………………(full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

I understand that I am at liberty to withdraw from the project at any time, should I so desire.

SIGNATURE OF PARTICIPANT DATE

……………………………………………………………………………………………

This page is to be retained by researcher

APPENDIX IX – ETHICAL CLEARANCE CERTIFICATE

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

10 June 2019

Mr Blessward Ngonidzashe Chinhoi (218083307)
Graduate School of Business & Leadership
Westville Campus

Dear Mr Chinhoi,

Protocol reference number: HSS/0203/019D
Project title: Implementation of lean manufacturing framework for Sugar Industry in Mozambique

Approval Notification – Expedited Application

In response to your application received on 13 March 2019, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL**.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 1 year from the date of issue. Thereafter Recertification must be applied for on an annual basis.

[redacted]g you everything of the best with your study.

....

Dr Rosemary Sibanda (Chair)

/ms

Cc Supervisor: Professor Muhammad E Hoque
cc Acting Academic Leader Research: Dr Emmanuel Mutambara
cc School Administrator: Ms Zarina Bullyraj

Humanities & Social Sciences Research Ethics Committee
Dr Rosemary Sibanda (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 3587/8350/4557 **Facsimile:** +27 (0) 31 260 4609 **Email:** ximbap@ukzn.ac.za / snymanm@ukzn.ac.za / mohunp@ukzn.ac.za
Website: www.ukzn.ac.za

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

30 August 2022

Blessward Ngonidzashe Chinhoi (218083307)
Graduate School of Business & Leadership
Westville Campus

Dear BN Chinhoi,

Protocol reference number: HSS/0203/019D
Project title: Implementation of lean manufacturing framework for Sugar Industry in Mozambique
Amended title: A lean manufacturing implementation framework for improved productivity and efficiency in the sugar industry in Mozambique

Approval Notification – Amendment Application

This letter serves to notify you that your application and request for an amendment received on 25 August 2022 has now been approved as follows:

- Change in title

Any alterations to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form; Title of the Project, Location of the Study must be reviewed and approved through an amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

Best wishes for the successful completion of your research protocol.

Yours faithfully

[redacted]

....

Professor Dipane Hlalele (Chair)

/ms

Humanities & Social Sciences Research Ethics Committee
UKZN Research Ethics Office Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Tel: +27 31 260 8350 / 4557 / 3587
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