BOTSWANA INTERNATIONAL UNIVERSITY
OF SCIENCE & TECHNOLOGY

Implementation of Lean Manufacturing tools in an abattoir: A Case Study of a Botswana Private Beef Abattoir

BY

BABEDI KUFIGWA

Meng Industrial and Manufacturing

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August 2020

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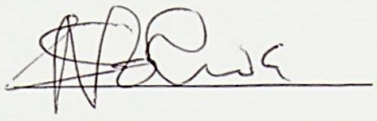
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CERTIFICATION

The undersigned certifies that he/she has read and hereby recommends for acceptance by the Faculty of Engineering & Technology a dissertation/ thesis titled:

Implementation of Lean Manufacturing Tools in an abattoir: A Case Study of a Botswana Private Beef Abattoir.

in fulfillment of the requirements for the degree of Master of Engineering in (*Industrial and Manufacturing Engineering*) of the BIUST



Dr. Norman Gwangwava

(Supervisor)

Date: 07/09/2020

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Table of Contents

DECLARATION AND COPYRIGHT ii
CERTIFICATION iii
ACKNOWLEDGEMENTS iv
Abstract viii
List of publications ix
List of figures x
List of tables xii
List of abbreviations used xiii
Chapter 1 : Introduction 1
1.0 Motivation 2
1.1 Background 2
1.2 Problem statement 5
1.3 Aim 6
1.4 Objectives 6
1.5 Research justification 6
1.6 Guide to the thesis 6
1.7 Chapter conclusion 7
Chapter 2 : Literature review 8
2.0 Introduction 8
2.1 Beef industry in Botswana 8
2.2 Lean manufacturing tools 9
2.3 Productivity 10
2.4 Lean Manufacturing as a tool to improve productivity 11
2.5 Lean manufacturing tools and techniques 11
2.5.1 5S (the Japanese lean tool for improving the workplace) 12
2.5.2 Value Stream Mapping 12
2.5.3 Just-In-Time 14
2.5.4 Continuous improvement (kaizen) 14
2.5.5 Layout design 16
2.5.6 Work standardization 19

2.5.7 Waste management and Utilization 20
2.5.8 Work-Study and Time study 21
2.5.9 Lean Manufacturing, Practices, Philosophies and Lean Sigma Methodologies Applied in Abattoirs 29
2.5.10 Beef slaughter process 31
2.5.11 PDCA cycle 33
2.5.12 Define-Measure-Analyze-Improve-Control (DMAIC) technique 34
2.6 Chapter conclusion 34
Chapter 3 : Methodology 35
3.0 Introduction 35
3.1 Qualitative Approach 35
3.2 Chapter conclusion 40
Chapter 4 : Implementation of lean tools 41
4.0 Introduction 41
4.1 Illustrations before lean implementation 41
4.2 Roadmap to lean implementation 60
4.3 5S Implementation 61
4.3.1 5S Objectives and goals 63
4.3.2 5S Council 68
4.3.3 Conducting 5S Training meeting plan 68
4.3.4 Summary of 5S progress 69
4.4 Work method (method study and time study) 70
4.5 Value Stream Mapping, Takt and Cycle times 74
4.6 Chapter conclusion 79
Chapter 5 : Results and discussion 80
5.0 Introduction 80
5.1 Discussion 89
5.2 Research limitations 91
5.3 Chapter conclusion 92
Chapter 6 : Conclusion & recommendation 93
6.1 Research deliverables and achievements 93
6.2 Future directions and recommendations 94

6.3 Recommendations to the abattoir 95
6.3.1 5S recommendations 95
6.3.2 Process documentation 96
6.3.3 General recommendations in the abattoir's operation 96
6.3.4 Value stream mapping 97
6.4 Summary of the research 100
References 101
Appendices 107
Appendix A: Interview questions 107
Appendix B: Questionnaire 108
Appendix C: 5S Audit checklist 109
Appendix D: Waste identification form 111
Appendix E: 5S Proposing letter for forming 5S team Council 112
Appendix F: 5S Training Manual document to be used for 5S training awareness 113
Appendix G: Future proposed business process map after consultation 120
Appendix H: Motion study results of production section 121
Appendix I: Time study sheet 139
Appendix J: Observed Time study results for five cycles 140
Appendix K: Standard time results 141
Appendix L: List of equipment and tools used in the slaughtering of cattle 142
Appendix M: Detailed process of slaughtering of a beast 143
Appendix N: Proposed Template of Business and Production Process Documentation 144
Appendix O: Future State Map 146
Appendix P: Publication with Industrial Engineering and Operations Management Conference (IEOM) 147
Appendix Q: Publication with BIUST, RDAIS 2019 148

Abstract

Successful implementation of lean manufacturing tools and methodologies can help improve production targets, productivity and strengthen process improvements. The abattoir was experiencing long manufacturing lead time, inconsistency and unclear flow of work, a cluttered workplace that is hazardous to employees' safety and undocumented process which makes it difficult to have a standardized way of doing work. The aim of carrying out the study is to support local abattoirs and help them strengthen their processes through implementation of lean tools. Interviews, questionnaires, and review of company documents were research instruments that were used to investigate issues or problems that the company was facing. Plan, Do, Check and Act phase was chosen over DMAIC (Define-Measure-Analyze-Improve-Control framework) because it supports lean implementation projects for continual improvement, provides a scientific, systematic approach for addressing process improvement and continuous operations improvement. Another reason the author used Plan, Do, Check and Act methodology was because there was no current data or metrics that the abattoir was using as baseline to measure current status. Work-study (i.e. time and motion study), 5S, process flow mapping, value stream mapping and root cause analysis were tools that were implemented. Results before implementing lean techniques, tools and practices indicated that employees spend most of the time idle without doing anything, due to unclear flow of work and improper work allocation. Employees also carry skinned head using their backs hence leading to more back pains and more sick leave. It was also noticed within the abattoir's process that there is more delay time spent for inspection to take place and high transporting time for skinned heads due to the holding tray placed far away (about 30 meters away from the production line). There wasn't a specific time frame for detaining carcass that is found with measles after inspection, i.e. some employees preferred to detain three days, some five and some seven and this affected flow of work within the abattoir. During lean implementation, time study was conducted to determine standard times in the production line, to eliminate non-value-adding activities consumed within the value chain and in the process flow. 5S principle was implemented for workplace organization. Value stream was implemented to identify bottlenecks and to understand the abattoirs value proposition. Process mapping was implemented to help operators to deliver carcass efficiently and consistently to reduce non-value adding activities. Recommendations such as introduction of carcass tagging, proper arrangement of trays, process flow mapping initiative and worker balance were made to the abattoir. Implementation of lean in abattoirs is not common since it was only implemented in various farms (United Kingdom) and meat processing industry (United Kingdom Red Meat) and these industries were implementing five principles of lean and value stream mapping respectively. For lean implementation to be sustainable there should be a good organizational culture and readiness. Organizational culture is important as it seeks to address areas for improvement in terms of organizational processes, products, customer requirements/ value, types of demand and leadership styles. Most abattoirs should view lean implementation as a strategy tool which can achieve impacts in improved time, cost savings, service quality as well as employee morale and satisfaction.

List of publications

The author published three papers. The first paper that the author published was with Industrial Engineering and Operations Management society, titled "Implementation of lean manufacturing tools in an abattoir: A case study of a Botswana Private Abattoir", and the other second publication was with Botswana International University of Science and Technology during BIUST Research & Innovation Symposium 2019 (RDAIS 2019), titled "Productivity Improvement using Value Stream Mapping in a beef abattoir". The third publication was with African Operations Management Conference held by UNISA titled "Implementing 5S in a beef abattoir".

List of figures

Figure 1-1: Employment by type of employer, BIDPA estimates (Source: Jefferis, 2007) 3
Figure 1-2: Map of regions of Botswana showing protection zones in terms of FMD (Source: Director of Food and Veterinary Office, 2015) 5
Figure 2-1: Productivity process (Source: Timothy e.t.al 2005) 11
Figure 2-2: Detailed value stream map (Source: Administrator, 2018) 14
Figure 2-3: Muther's Systematic Layout Planning 18
Figure 2-4: Basic Maynard Operation Sequence Technique (Source: Chary, 2009) 22
Figure 2-5: Method study symbols (Source: Ergonomics, 2016) 24
Figure 2-6: Method study symbols for recording the facts (Source: Rathod et.al., 2016) 25
Figure 2-7: Two-handed process chart (Source: Rathod et.al., 2016) 26
Figure 2-8: Therbligs used in Industrial Engineering (Souce: Ergonomics, 2016). 27
Figure 2-9: Generic process flow in a beef abattoir (Source: International Meat and Poultry HACCP Alliance, 1996) 32
Figure 2-10: Live beast and a carcass (Source: Silverwind Botswana, 2015) 33
Figure 2-11: An operator separating carcass 33
Figure 2-12: PDCA model (Source: Keith, 2015) 34
Figure 4-1: Process flow of Botswana Private Abattoir 44
Figure 4-2: Current business Process map of Botswana Private Abattoir 48
Figure 4-3: Current value stream map 49
Figure 4-4: Complaints recorded in the month of April and May 49
Figure 4-5: 5S scoring sheet 51
Figure 4-6: No labels of tools and signs not indicating the actual location of the equipment 52
Figure 4-7: No sign panels and floor markings and tools not ergonomically stored 52
Figure 4-8: Botswana Private Abattoir facility layout. 53
Figure 4-9: Improper managing of electric cables 54
Figure 4-10: Roadmap to 5S implementation (Source: Administrator, 2018) 62
Figure 4-11: Radial charts of 5S phases in summary 66
Figure 4-12: Pareto graph for 5S performance results 67
Figure 4-13: 5S team council 68
Figure 4-14: 5S training meeting plan 69
Figure 4-15: Current cycle times 75
Figure 4-16: Current worker balance chart 76
Figure 4-17: Graph of production for the month of April 2018 77
Figure 4-18: Cause and effect diagram for not meeting the production target 79
Figure 5-1: Cause and effect diagram for missing carcass within the production facility to the end user or customer 81
Figure 5-2: Improvements before vs. after lean implementation 82
Figure 5-3:Complaints recorded before and after lean implementation 83
Figure 5-4:Comparison of times (work study exercise) 84

Figure 5-5: 5S achievement 85
Figure 5-6: Comparison of value added time before and after lean implementation 86
Figure 5-7: Manpower requirements before and after implementation 87
Figure 5-8:Comparisons of efficiencies before and after implementation 88
Figure 5-9: Proposed lean implementation framework in a beef abattoir 91
Figure 6-1: Proposed design layout to address safe workplace organisation 97
Figure 6-2: Future worker balance chart 99

List of tables

Table 2-1: Lean practices, policies, and philosophies (Source: Senthikumar & Sampath, 2012) 10
Table 2-2: Standardized work methods (Source: Kumar, 2018) 19
Table 2-2: Ground wastewater / Sanitation Technologies and their application 20
Table 2-4: MOST parameters (Source: Chang et.al., 2013) 22
Table 2-5: Therbligs abbreviation and its meanings 27
Table 2-6: Two hand process chart of an operator stunning a beast (refer to Table 2.5 for therbligs symbols) 29
Table 2-7: Literature sources of lean implementation in abattoirs 31
Table 3-1: List of participants 38
Table 3-2: Sample questionnaire for participants 40
Table 4-1: PDCA and DMAIC problem-solving approaches (Source: Najmi & Sidhu, 2019) ... 42
Table 4-2: Area of interest identified during a plant tour 42
Table 4-3: SIPOC high-level entities 43
Table 4-4: Non-value-adding activities 45
Table 4-5: Complaints and issues recorded in a production line with their frequency of occurrence 47
Table 4-6: Roles for the compilation of standard operating procedures 56
Table 4-7: Process steps involved when cattles enters the building at the gate 57
Table 4-8: Process steps involved at the lairaging kraal 57
Table 4-9: Process steps in a production line 59
Table 4-10: Roadmap to lean implementation 62
Table 4-11: Audit performance (refer to Appendix C for assessment form) 64
Table 4-12: Cumulative frequency of criteria areas 67
Table 4-13: 5S implementation status 70
Table 4-14: Summary of motion study results (in minutes) using therbligs 73
Table 4-15: Summarized standard times in each section 73
Table 4-16: Summary of standard times in categorized sections 73
Table 4-17: Number of workers absent during production days 77
Table 4-18: Current state of the value stream 78
Table 5-1: Comparison of times before and after lean implementation 84
Table 5-2: 5S achievement quantified in terms of implemented phases and their percentages ... 85
Table 5-3: 5S implementation summary 90
Table 6-1: Current State vs. Future State 99

List of abbreviations used

HACCP– Hazard Analysis Critical Control Points

DVS – Department of Veterinary Services

GDP- Gross Domestic Product

PDCA- Plan, Do, Check, Act

JIT- Just in Time

VSM-Value Stream Mapping

WIP- Work in Progress

SLP- Systematic Layout Planning

ISO- International Standards Organization

EU- European Union

EDD- Economic Diversification Drive

Meng- Master of Engineering

INME- Industrial and Manufacturing Engineering

BIUST- Botswana International University of Science and Technology

5S- the Japanese lean tool for improving the workplace meaning Seiro (Sort), Seiton (Set in order), Seiso (Shine), Seiketsu (Standardize) and Shitsuke (sustain)

SMED- Single Minute Exchange of Dies

PTY- Proprietary

LTD- Limited

BIDPA- Botswana Institute Development Policy Analysis

BEDIA- Botswana Export and Development Authority

BMC- Botswana Meat Commission

BOPA Botswana Publication Agency

UK- United Kingdom

SCM- Supply Chain Management

SIPOC- Supplier, Input, Process, Output, and Customer

SHE- Safety and Healthy Environment

FVCA- Food Value Chain Analysis

SMME- Small-to-Medium and Micro Enterprise

SOP- Standard Operating Procedures

TPM- Total Productive Maintenance

VM- Visual Management

W.S- Work benches & surfaces

QC- Quality Control

TQM- Total Quality Management

QMS- Quality Management System

MOST- Maynard Operation Sequence Technique

SIMO- Simultaneous Motion Chart

SOP – Standard Operating Procedure

FMD- Foot-and-Mouth Disease

TMU- Time Measurement Unit

PFD – Personal, Fatigue and Delay

NT- Normal Time

OT- Observed Time

Chapter 1 : Introduction

Technology is quickly advancing; organizations have to respond to increased customer's needs and remaining competitive by reducing costs and making sure that there is consistency in running day to day operations. For operations to be consistent; workflows and processes need to have low variations and be standard across the business. When processes are standardized it becomes easy to optimize, identify bottlenecks and remove those root causes. Process optimization enables companies to identify bottlenecks, inefficiencies, non-value adding tasks within production and process flow to eliminate tedious tasks and reduce operating costs. The purpose of implementing lean manufacturing tools in industries is to manage the aspect of process improvement (Environmental Agency, 2017). This research was conducted at Botswana Private Beef Abattoir targeted at the implementation of lean manufacturing tools in beef abattoirs. The purpose of carrying out the research in a local beef abattoir was to support local companies so that they improve their processes for operational efficiency.

Operation efficiency and process optimization enable organizations to achieve sustainable operations, reduce operational cost, deliver and produce better quality products in a safer manner and faster. Organizations that have embarked on lean implementation projects have noticed massive savings such as Red Meat Industries, which saved about 2-3% on its value chain, and some also experienced other benefits including doubled productivity, improved service, quality and speed, lower error rate by 80%, reduce work in progress by 50% and staff satisfaction (Willcocks & Lacity, 2016). The case study company is affected by production inefficiency, unclear process flow (i.e. there are no standard ways as to how the activities should flow in the production process), un-optimized business processes, long manufacturing lead time, and does not have operating procedures which are documented. In the case study company, there is no how work should flow, everyone just does work as it arises and these become a risk as it leads to more lead time, uncontrolled workflow, unbalanced work in terms of work allocation to employees. Moreover, these challenges affect the company as it is unable to deliver reliable products timely, high-quality service and contributes to high operational cost.

Lean manufacturing tools that were successfully applied are Value Stream Mapping (VSM), Root Cause Analysis (RCA), Time Study and 5S. Plan- Do –Check and Act (PDCA) problem-solving framework was followed when conducting this research and during lean implementation. Value stream mapping was implemented to find abattoirs wastes and try to eliminate the pitfall. Root cause analysis was used to further investigate process inefficiencies that the abattoir experiences. Time study was used to find time duration of value-adding and non-value adding activities in a process flow. 5S was used to find out workplace arrangements in the abattoir. PDCA was chosen over DMAIC (Define-Measure-Analyze-Improve-Control framework) because it supports lean implementation projects for continual improvement, provides a scientific, systematic approach for addressing process improvement and

continuous operations improvement. In the journey of lean implementation; key roles for lean implementation, setting clear goals and expectations, implementation focus (i.e. meetings, facilitation events and implementation training) were established.

Results were shown in three phases, first being the illustrations before lean implementation/processes, the second phase being the elimination of non-value adding activities (waste) and the actual implementation, and the third phase was showing the effectiveness of lean implementation tools, and those optimizations made in the abattoir's processes. Organizations need to understand that to strengthen processes in abattoirs; management and employees need to have an appropriate process improvement team including change management that will be continuously monitoring process changes and documenting them. Chapter one introduces the research background, the motivation behind carrying this research, aim and objectives, the background of lean tools implementation in abattoirs, research justification and guide towards this document.

1.0 Motivation

The motivation behind writing this research is to help local abattoirs in Botswana to optimize production/ business processes for operational efficiency improvement. The case study abattoir is categorized as a medium enterprise and it is one of the key players in Botswana's micro-economy. Private abattoirs and SMMEs in Botswana are seen to be a potential source of employment of unskilled and semi-skilled employees thus their development is important in combating unemployment (Mukras, 2003).

1.1 Background

The case study private abattoir is operated by Mansaga (Pty) Ltd, A company registered in Botswana owned by Batswana citizen directors. The company's Head office is in Palapye village, which is a rural-urban area. It started its operation in 2014 (Silverwind Botswana, 2015). The company provides slaughter services and detains cattle for local farmers and individuals who are their key customers, enabling the company to remain competitive in the industry. Currently, its apparent challenges affecting efficiency; the company is unable to reach its goals and objectives. The use of lean tools has helped the company to reduce non-value adding activities and efficiency in their manufacturing processes and value chain. The company wants to constantly advance and increase its client base through standardizing processes, and to have a consistent flow of work. The company also looks forward to providing services to its clients on its operational excellence standards and not compromising those standards in search of growth (Silverwind Botswana, 2015). Due to undocumented processes, non-value adding activities, and unclear flow of work, the company is unable to reach a production target of 70 cattle in a day. From Botswana Institute Development Policy Analysis, estimates show that

SMMEs account for 50% of private employment in Botswana, Jefferis (2007); of which this 32 % consist of 14 % of micro, 14% of small and 4% of medium enterprises. This is shown in Figure 1-1.

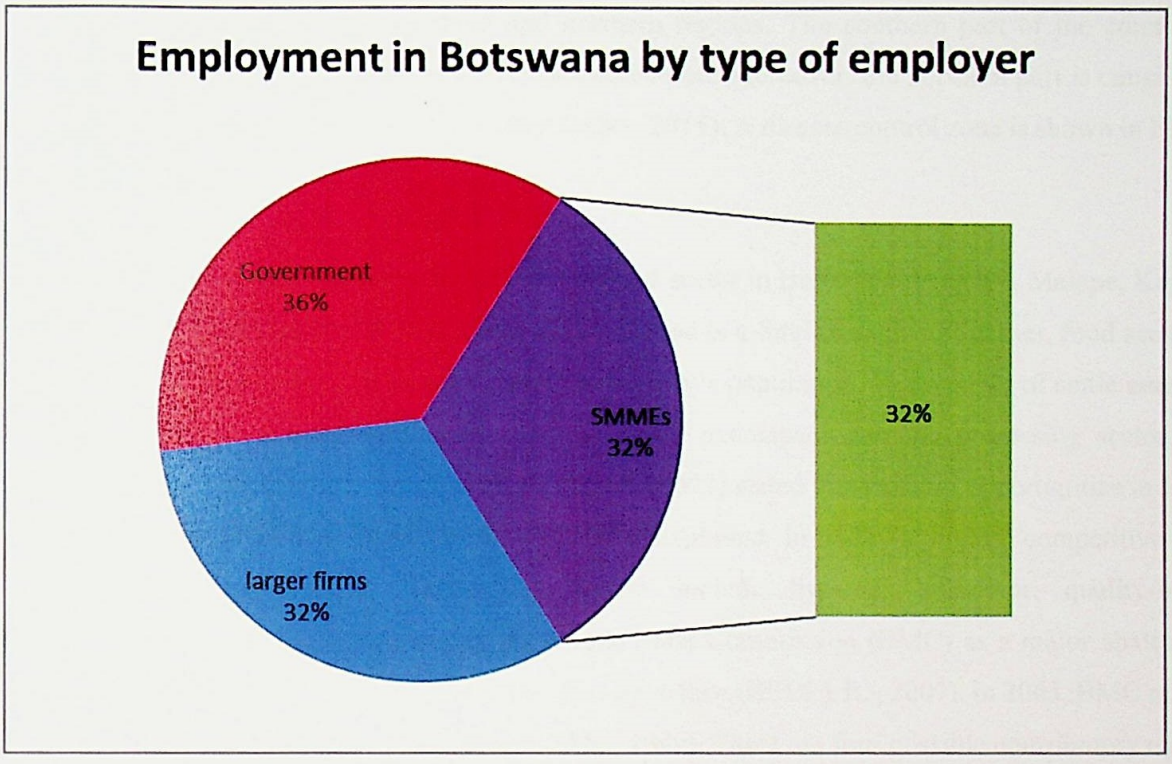


Figure 1-1: Employment by type of employer, BIDPA estimates (Source: Jefferis, 2007)

In Botswana, SMMEs are predominately owned by citizens with larger enterprises being foreign-owned (Jefferis, 2007). The developments of the manufacturing SMME sector contribute to the development of entrepreneurial and managerial skills that will over time give birth to entrepreneurs capable of running larger firms (Jefferis, 2007). It is thus vital to develop abattoir SMMEs such as Botswana Private Abattoir in a bid to diversify Botswana's economy and increase the contribution of the manufacturing sector. The development of manufacturing SMMEs also holds the potential to transform Botswana's economy from a resource-based economy to a knowledge-based economy. This is a critical move, in consideration of the fact that mineral resource dependency is not sustainable due to the non- renewable nature of mineral resources.

Botswana is a country of 580, 000 km^2, with a livestock population of about 2.5 million cattle, 1.5 million sheep, and goats (The Director of Food and Veterinary Office, 2015). Foot and mouth disease

(FMD) are one of the disease conditions that hamper the beef industry in Botswana. Wild buffalos are considered as a life-long asymptomatic carrier of the FMD virus. Due to the outbreak of FMD disease, Botswana was regionalized as southern and northern regions. The southern part of the country is recognized as FMD free zone and free without vaccination. Moreover, the northern part is considered infected (The Director of Food and Veterinary Office, 2015). A disease control zone is shown in Figure 1-2 below.

Beef is the most important component of the agri-food sector in Botswana (Engelen, Malope, Keyser, & Neven, 2013). The authors further stated that agri-food is a foreign exchange earner, food security, and a source of income for a large segment of the country's population. The number of cattle entering the value chain is constrained resulting in significant overcapacity in the processing sector and consequently low profitability for processors. Mulale (2002) stated that existing opportunities in local, regional, and international markets are largely unexploited in today's highly competitive and globalizing agri-food sector. Those key factors include livestock subsector, quality-based differentiation, and reliability of supply. Botswana Meat Commission (BMC) as a major abattoir in Botswana it is running through losses in every year since then (BEDIA B. , 2007). In 2003, BMC posted its poorest trading results since its inception (BMC, 2009). There are four possible contributory causes to these losses, even though they are not mutually exclusive (BEDIA, 2007). This is; declining prices for beef exports – either absolutely or relative to domestic prices, extra-Botswana costs rising faster than revenue, intra-Botswana costs rising faster than revenue, and declining efficiency in BMC (BMC, 2009).

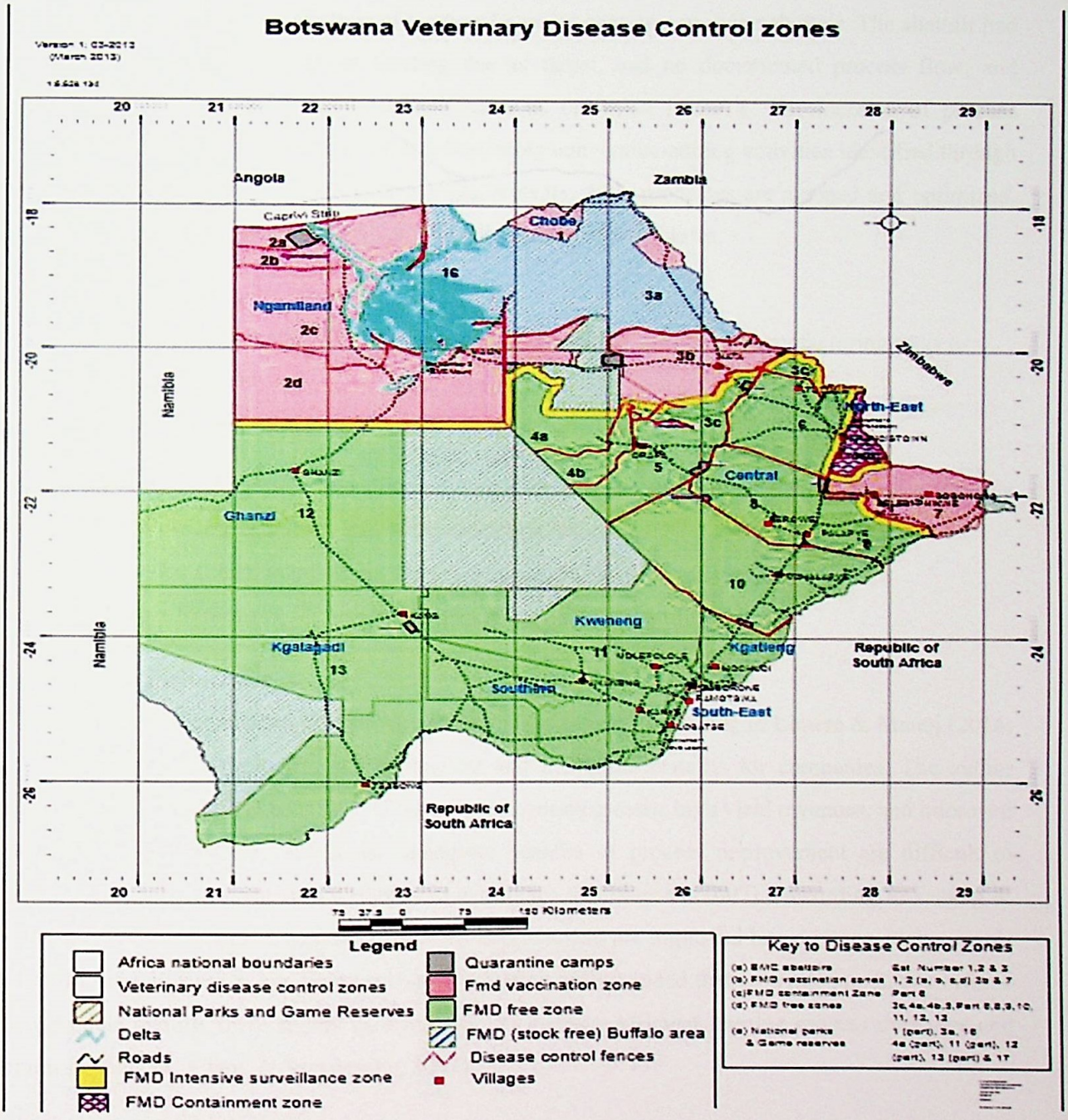


Figure 1-2: Map of regions of Botswana showing protection zones in terms of FMD (Source: Director of Food and Veterinary Office, 2015)

1.2 Problem statement

The case study company is unable to meet the set production target of 70 cattle in a day due to un-optimized production processes in the abattoir's production line, with no standard operating procedures

which are hindering the smooth flow of work and process consistency in the abattoir. The abattoir had three consecutive months without meeting the set target, had no documented process flow, and documented standard operating procedures since its operation in 2014. The increase of process efficiency by 13-20 % can be achieved by eliminating non –value-adding activities identified through mapping workflows and conducting time measurements. After processes are mapped and optimized, they can later be documented to establish standard operating procedures.

1.3 Aim

To strengthen the local abattoir industry processes in Botswana using lean manufacturing tools to achieve process efficiency.

1.4 Objectives

i. To identify the existing process, analyze and optimize it is using lean manufacturing tools to achieve about 13 -14% process efficiency and workplace organization

ii. Carry out value stream mapping for the organization to identify bottlenecks

iii. To develop a framework for lean implementation in a beef abattoir

1.5 Research justification

This research was conducted to improve processes in abattoirs. According to Limere & Manoj (2016) process improvement initiative yields tangible and intangible benefits for companies. The author further states that tangible benefits include reduced operating costs, high yield revenues, and improved compliance with industry standards. Intangible benefits of process improvement are difficult to measure but are important for an organization's image (Sofokleous, 2007). According to Luning & Marcelis (2009), intangible benefits of process improvement are improved brand image, higher levels of customer satisfaction, and time savings. The author further added that to create maximum volume and product quality, there should be a measure; to measure efficient farming process measures and controls (Colgan, Adam, & Topolansky, 2013).

1.6 Guide to the thesis

This document is organized in the following chapters;

Chapter 1: Introduces the research, with giving a detailed background, objectives research justification

Chapter 2: It contains literature and sources that reviews applications of lean tools in meat processing industries, abattoirs processes, and agriculture

Chapter 3: This chapter contains the methods used for the research, methodology approaches used and research instruments used.

Chapter 4: This chapter illustrates research findings, results of interviews conducted, questionnaire survey results, results from investigations before implementing lean tools, pre-existing results, and the actual implementation results.

Chapter 5: This chapter reports the results of the effectiveness of eliminating non-value adding activities in a process flow, the effectiveness of lean implementation tools research limitations, and recommendations

Chapter 6: This chapter concludes by reporting on research deliverables, achievements, recommendations, future directions, and roadmap to future research, and the summary of the research. References and Appendices are sections that support this document in terms of books and literature sources used.

1.7 Chapter conclusion

This chapter outlined the introduction of the research, aim and objectives, the background of the research and research justification. The purpose of conducting this research was to strengthen processes in abattoirs. The introduction in this chapter gave readers an insight into what motivated the author to write this paper. It also justifies successful lean implementation projects and tools that have implemented in meat processing industries or abattoirs. This chapter also goes on to guide readers on how the thesis is structured.

Chapter 2 : Literature review

2.0 Introduction

The purpose of the literature review in this document is to discover what has been studied about lean implementation tools, techniques, and methods to solve production inefficiency and productivity. The structure of this literature review section was done. First, a literature review on productivity and lean manufacturing tools was done to give a better indication and explanation of lean manufacturing. Then the review deepens by indicating some lean tools that are used for productivity improvement and lean implementation projects. Literature sources, case study reports on lean implementation were used to highlight how lean has been applied in farming, beef abattoir, meat processing industry, and in agriculture.

2.1 Beef industry in Botswana

Most Botswana families own cattle, numerous Batswana are a stakeholder in and potential beneficiary of government support to the beef value chain. It is thus particular difficult for policymakers to evaluate the impact of measures and to reach policy and strategy decisions that would facilitate urgently needed changes in the beef value chain to maximize social welfare for the population as a whole and to benefit both smallholder and large scale farmers (BEDIA B. , 2007). According to Engelen, e.t.al (2013), cattle are both a production good that is being a draught power, transport and calves, and consumption good (as milk, meat & hides) and a form of saving for future consumption and production. Cattle production in Botswana is highly cyclical, depending upon rainfall and pricing structures (Mulale, 2002). Farmers sell animals during droughts, flooding the market with poor-quality animals and driving prices down, and they rebuild their herds when rainfall is good reducing the number of animals for sale and driving up prices (Engelen, Malope, Keyser, & Neven, 2013).

According to Mulale (2002), Botswana is Africa's largest beef exporter ranked 18th in the world with a share of 0.5 percent in total world exports in value terms. Steven & Kennan (2005) stated that the beef sector in Botswana is estimated to account for less than 2% of Botswana's GDP and 1.5% of its merchandise exports. Furthermore, Mulale (2002) explained that the price differential is in part due to the retailers in the high-end market in Europe, with a world beef trading volume of only 14 percent of overall world production, trade and prices are easily disturbed if supply from a major exporting country drops or demand in a major importing country suddenly increases. Botswana struggles with branding

and the beef product they are producing hence losing market share to its competitors (Mulale, 2002). Botswana cattle industry uses free-range and natural farming methods, which ensure full-flavored and lean beef of the highest quality. Botswana's land and its subtropical and semi-arid climate is ideally suited for cattle farming and has been highlighted as a strategic sector within the country's Economic Diversification Drive (BEDIA B. , 2007).

Weaknesses in the country's cattle traceability system prevented access to the important EU market for 19 months in 2011-2012 and caused large disruptions in the domestic market due to the resulting surplus (Mulale, 2002). Moreover, exports have been rising steadily over the last two decades, but the 2007-2008 global crisis and a suspension from the EU market in 2011 and 2012 because of failure to comply with standards have caused declines. Glacier (2018) stated most countries like Botswana export more beef outside the country but there are still countries that sell more of its beef in small markets and trust local butchers. The author further stated that countries like India control food safety and product distribution in a way that they put restrictions limits on beef exports/imports. In terms of micro-economic Silverwind, Botswana (2015) stated that countries that have more micro-economy make beef by-products such as uniforms marbled looking product. The author further stated that some micro-economy lies when local beef abattoirs supply local markets such as local butchers, hotels, retailers, and make beef by-products such as canned beef products and leather shoes. Countries that focus on promoting local markets must establish good policies that monitor food safety, market price control, control beef distribution in a way that limits local markets to end up opting for exports (Glacier, 2018).

2.2 Lean manufacturing tools

Lean is a methodology that relies on a collaborative team effort to improve performance by systematically removing waste and reducing variation (Naslund, 2008). It combines lean manufacturing/lean enterprise and Six Sigma to eliminate the eight kinds of waste (Muda). These lean wastes are defects, overproduction, waiting, non-utilized talent, transportation, inventory, motion, and extra-Processing (George, 2003). Table 2-1 below illustrates lean philosophies, policies, and practices. Lean methodologies were first applied at U.K Red Meat Industry which is a beef abattoir. A case study samples application and implementation of a lean tool for process improvement, optimization, and the report is titled "Lean transformation in the Agri-business Sector". Lean tools that were used and explored are value stream mapping, efficient consumer response, and value chain analysis (Zokaei & Simons, 2006).

Table 2-1: Lean practices, policies, and philosophies (Source: Senthikumar & Sampath, 2012)

Lean philosophies	**Lean policies**	**Lean practices**
Waste elimination	Total productive maintenance	Standardized work
Striving on perfection	Cooperation and transparency in the supply chain	Takt- time
Kaizen (continuous incremental improvements)	Visual control	5S
Systemic processual approach	Poke – yoke	Kanban
Focus on consumer value	Enhanced employee participation	
	Level production autonomation	

2.3 Productivity

Productivity is the relationship between the outputs generated from a system and the inputs that are used to create those outputs. It is concerned with the efficiency and effectiveness with which goods and services are produced. Productivity makes sure that the inputs used are utilized in an efficient way when they are being processed by machines into the final product. Efficiency measures the resources expected to be consumed to the resources consumed and effectiveness measures what the system sets out to accomplish with what was accomplished; plan vs. actual (Timothy, Dodla, Christopher, & George, 2005). Productivity in abattoirs is investigated through the use of time study, determination of standard times, standardized work, Takt –time (or drum-beat) production smooth flow, process mapping, value stream analysis and other necessary measurements for productivity such as labor productivity and efficiency (Barber, Etchells, Meltcalf, & Jakeman, 2012). Moreover, Aral & Sakarya (2010) carried out a study to determine unproductive times, and elapsed times in Turkey slaughterhouses. Figure 2-1 below shows a productivity process.

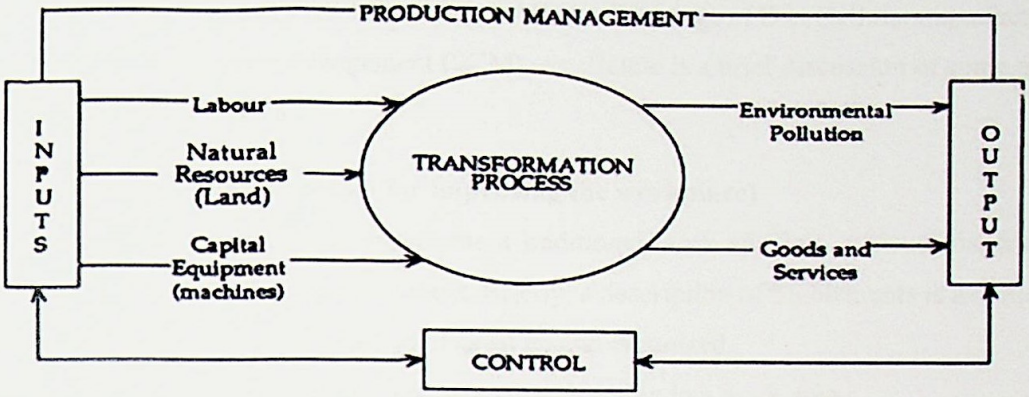


Figure 2-1: Productivity process (Source: Timothy e.t.al 2005)

2.4 Lean Manufacturing as a tool to improve productivity

Manufacturing operations are continually striving to increase the productivity and output of their operations. Their goal is to satisfy the customer with the exact product, quality, and price in the shortest amount of time. To achieve this objective of increasing productivity, lean manufacturing is put in place. Lean manufacturing is more than a cost reduction program or a problem-solving idea (Singh, Sharma, & TarumGupta, 2014). Lean practices that were adopted by the U.K beef abattoir are Takt-time for smooth continuous production flow and standardized work for continuous improvement for its supply chain value (Grynberg, 2014). Seven types of lean wastes: waiting, inventory, defects, overproduction, transport, motion, extra processing (Singh, Sharma, & TarumGupta, 2014). Benefits of using lean tools were stated by Denish & Thakkah (2014) as;

i. reduction in lead time,
ii. waste reduction,
iii. improvement in productivity,
iv. reduce cycle time,
v. reduction of unnecessary activity, and
vi. space and equipment utilization

2.5 Lean manufacturing tools and techniques

According to Denish & Thakkah (2014), the basic reason for lean manufacturing is to manufacture the product with minimum waste and continuous improvement of all activities and processes involved in any form of work. Lean uses the following key elements to achieve lean manufacturing; Kaizen (Continuous Improvement), 5S, Just in Time, Visual Management, Value stream mapping, Total

Productive Maintenance, TAKT time, Single Minute Exchange of Die, Cellular manufacturing (flexible operation), Supply chain management (SCM), etc. Below is a brief discussion of some of the key tools that were used.

2.5.1 5S (the Japanese lean tool for improving the workplace)

5S is a five-step process that transforms a traditional work site into a visual factory and lays the foundation for a Lean Enterprise System. Briefly, a description of 5S elements is as follows:

Sort: The first step in making things cleaned up and organized.

Set in Order: Organize, identify, and arrange everything in a work area.

Shine: Regular cleaning and maintenance.

Standardize: Make it easy to maintain, simplify, and standardize.

Sustain: Maintain what has been achieved

2.5.2 Value Stream Mapping

Value stream mapping is a lean manufacturing tool that originated from Toyota Production System (TPS) and uses techniques of lean manufacturing to analyze and evaluate certain work processes in a manufacturing operation (Apel, Li, & Walton, 2007). Value stream mapping (VSM) is used to find waste in the value stream of a product. Once the waste is identified, then it is easier to decide to eliminate it and the purpose of VSM is process improvement at the system level (Tyagi, Choudhary, Cai, & Yang, 2015). The key benefit to value stream mapping is that it focuses on the entire value stream to find system wastes and try to eliminate the pitfall (Hill, 2009). Grassi et.al (2014) explained value stream mapping in a product or a service as a flow of a sequence of activities from the beginning to end in a form of visual representation accompanied by lead times. The author adds that this tool is a core element of lean transformation because it gives a basic blueprint for various changes needed to move from a disconnected, dysfunctional flow kind environment one where material flows smoothly from one process to the next to the next, rather than making isolated improvements to individual activities within a larger value-adding process. QAD Enterprise Applications (2012) stated that value stream mapping provides an overall structure for applying other tools and kaizens, and for seeing beyond the symptoms of wastes to real root causes. Furthermore, the author stated that there are three essential parts in a value stream map, which information, material flow map, and lead time ladder.

Information flow- depicts the current state of the value stream map, observing the flow of data or information at the top of the map. Here the customer communicates daily requirements to the production control section via fax, verbal, email, or through a phone call.

Material flow- depicts the movement of product from raw material to finished product

Lead time ladder- summarizes the cycle times(i.e value-adding time in each process) per piece and it is contrasted with total time spent in the value stream.

Apel, Li, & Walton (2007) further stated that value stream mapping can be created simply using a pen or pencil, nevertheless more advanced maps are created using Microsoft Visio as well as excel. Moreover, the author further stated that VSM is divided into five basic steps which are identifying the product, creating a current VSM, evaluating the current map by identifying problem areas, creating a future state VSM, and lastly implementing the final plan. Hines & Nich (2001) explained that the first step in value stream mapping is choosing a specific product the VSM will focus on, then followed by creating an initial VSM current process. Atter the current map has been completed; the team evaluates the process and the process and the steps involved. All this data is then compiled on a map and analysis is performed. Sheehan (2016) alluded that on a typical VSM every step of the process is included. Furthermore, the author stated that parameters such as cycle time, Takt -time, work-in-progress (WIP), set up time, downtime, number of workers, and scrap rate are included in each step. Non-value-adding time will be shown at each step (Grassi, Co.Accountants, & Consultants, 2014). Moreover, the author stated that problem areas are identified after analyzing and evaluating the current process of the product. The last step of the value stream mapping process is to implement new ideas and thus turning a more efficient lean manufacturing process (Hines & Nich, 2001). Benefits of value stream map were stated by Grassi et.al (2012) as it helps to visualize more than the single process level, links material and information flow, provides a blueprint for implementation, and it ties together lean concepts and techniques. Moreover, the author explained that the future state is mapped after the current state has been mapped to eliminate waste, create flexibility, and creation of smooth flow. Below in Figure 2-2 shows a value stream map.

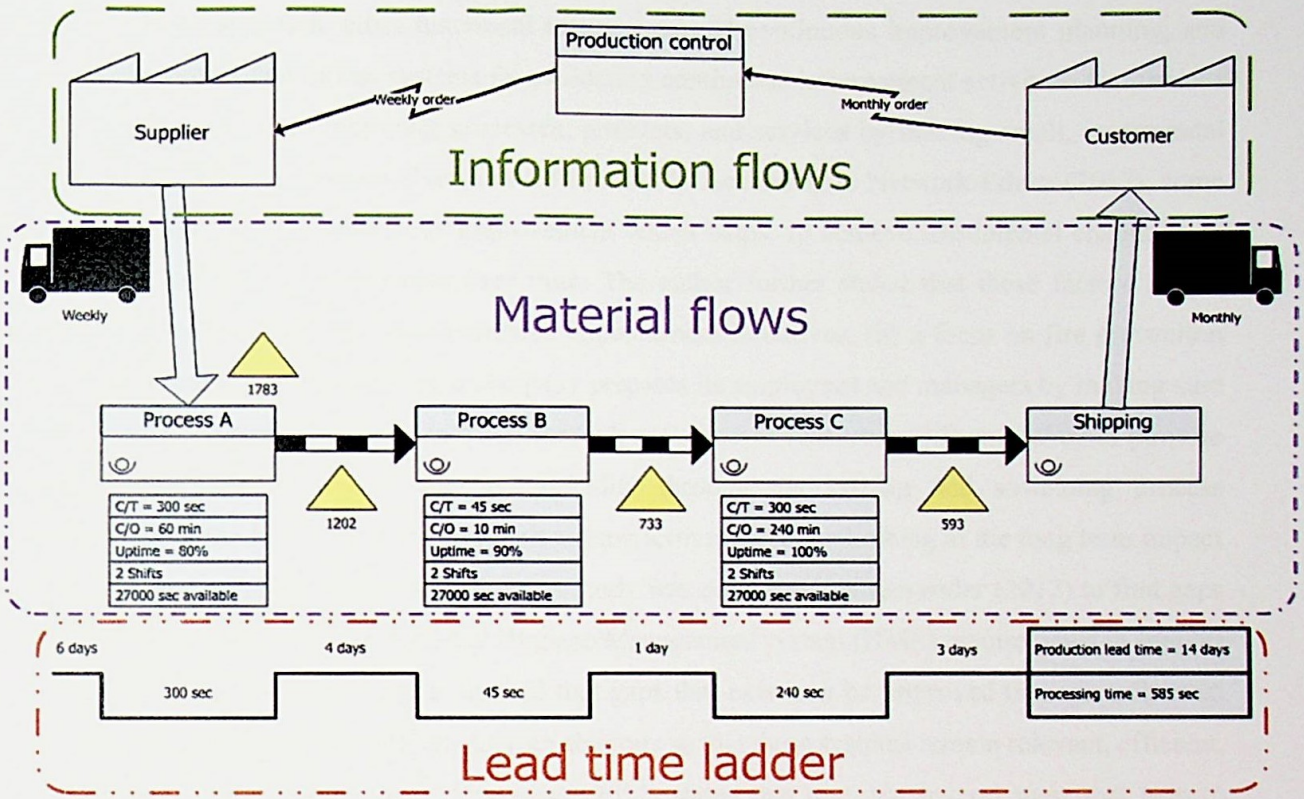


Figure 2-2: Detailed value stream map (Source: Administrator, 2018)

2.5.3 Just-In-Time

Just in time is an integrated set of activities designed to achieve high volume production using the minimal inventories of raw materials, work in process, and finished goods. Just in time is also based on the logic that nothing will be produced until it is needed (Shivanand, Benal, & Koti, 2006). It is commonly used to describe the stockless production manufacturing approach, where only the right parts are completed at the right time. Just-in-time reduces inventory, improves quality, and control cost. (Chiarini, 2013), defines just-in-time as a pull system where the parts are produced only when they are required.

2.5.4 Continuous improvement (kaizen)

According to (Gersten & Riis, 2002), continuous improvement (CI) can be defined as the planned, organized, and systematic process of on-going, incremental, and company-wide change of existing practices aimed at improving company performance. Activities and actions that simplify and enable the development of continuous improvement include problem-solving, plan-do-check-act (PDCA)

problem-solving approach, cross-functional teams, a formal continuous improvement planning, and management group, and formal systems for evaluating continuous improvement activities. Continuous improvement focuses on improving processes, products, and services by making small, incremental improvements within a business (Network Editor, 2017). According to Network Editor (2017), some factors that contribute to continuous improvement which helps to achieve incremental changes that will add up to major improvements over time. The author further stated that these factors are (i) leadership involvement in driving continuous improvement initiatives, (ii) a focus on fire prevention rather than fire fighting that is to say a company prepares its employees and managers by making sure that they have the mental capacity to do so through provision of resources, (iii) constancy of purpose by focusing on improvements and its criticality through maintaining and sustaining process improvement in the long long term, (iv) shift to long term mindset by looking at the long term impact of the work and mindset rather than actions. A study was conducted by Govender (2012) to find gaps that exist between their present regulated Hygiene Management system (HMS) requirements in support of continuous improvement. Results showed that gaps that exist can be improved through safe meat handling and processing at each South African abattoirs so that these systems remain relevant, efficient, and effective over time. Moreover, Yoskovitz (2012) stated that they are several steps that help to implement continuous improvement, which are;

i. Solicit feedback – involves observing results of failing processes by identifying root causes and being open to suggestions on how things are done
ii. Sharing more, not less- involves sharing information on what is going on, keeping everyone pointed in the same direction, reasoning behind directions and creating a collective expectation
iii. Document stuff – involves jotting down notes on processes such as customer handling inquiries and communication process between designers
iv. Don't automatically blame the tool – involves configuring how best a tool can be correctly used rather than changing it
v. Identify the change requirements – involves identifying your needs to change, process changes and top requirements
vi. Think lean – involves lean startup (i.e. build =>measure=>learn). When designing a process, pick an appropriate tool; define the goals that need to be achieved. It also entails time boxing the experiment and measures the results qualitatively and quantitatively.

2.5.5 Layout design

An effective layout can help an organization to achieve a strategy that supports differentiation, low cost, or response (Heizer, 2000). Layout design helps to improve higher utilization of space, equipment, and people. It also improves the flow of information, material or people and a safe working condition. Changes in markets call for a manufacturing system to adapt to stand competition. Due to changes in demands, product mix needs to change in product flow or machine utilization which further tends to need for change in plant layout (Kulkami, B, & H.M, 2015). Designing and placing a facility strategically to optimize production is called the facility layout problem. Shayan & Chittilappilly (2004) defined the facility layout problem as an optimization problem that tries to make layouts more efficient by considering various interactions between facilities and material handling systems while designing layouts.

The need for facility layout design arises both in the process of designing a new layout and in redesigning an existing layout. These are listed below:

i. Inefficient operations
ii. High costs
iii. Bottlenecks
iv. Changes in the design of products or services
v. The introduction of new products or services
vi. Changes in environmental or other legal requirements
vii. Changes in the volume of output or mix of products
viii. Changes in methods and equipment
ix. Accidents
x. Morale

(Amine, Henri, & Sonia, 2007), explained the following types of facility layout:

i. Product layout: Product layout is used for systems with high production volumes and a low variety of products. Facilities are organized according to the sequence of the successive manufacturing operations (Amine, Henri, & Sonia, 2007).
ii. Process layout: Process layout groups facilities with similar functions together (resources of the same type) (Amine, Henri, & Sonia, 2007).
iii. Fixed-position layout: In a Fixed product layout, the product's general circulates within the production facilities (machines, workers, etc.); in this layout, the product does not move, it is

the different resources that are moved to perform the operations on the product. This type of layout is commonly found in industries that manufacture large size products, such as ships or aircraft (Amine, Henri, & Sonia, 2007).

iv. Cellular layout: In a cellular layout, machines are grouped into cells, to process families of similar parts.

There are several traditional procedures used in layout design including:

i. Apple's Plant Layout Procedure (1977)
ii. Reed's Plant Layout Procedure (1961)
iii. Muther's Systematic Layout Planning (1961)

Muther's systematic layout planning (SLP) is currently and the most used procedure (Amine, Henri, & Sonia, 2007). Many of the automated layout design techniques like the Proplanner flow planner uses SLP procedure for solving facility layout problems. The methodology created by Richard Muther is summarized in Figure 2-3 below. Researchers such as Gomez further refined this method (Tak & Lyon, 2012). The overall procedures consist of three parts which are analysis, search, and selection. Material flow is traced using the "from-to matrix" between departments and an activity relationship analysis (Activity Relationship Chart). This chart collects the qualitative information of 'proximity ratios' which consists of a set of letters (A, E, I, O, U, X) (Tak & Lyon, 2012).

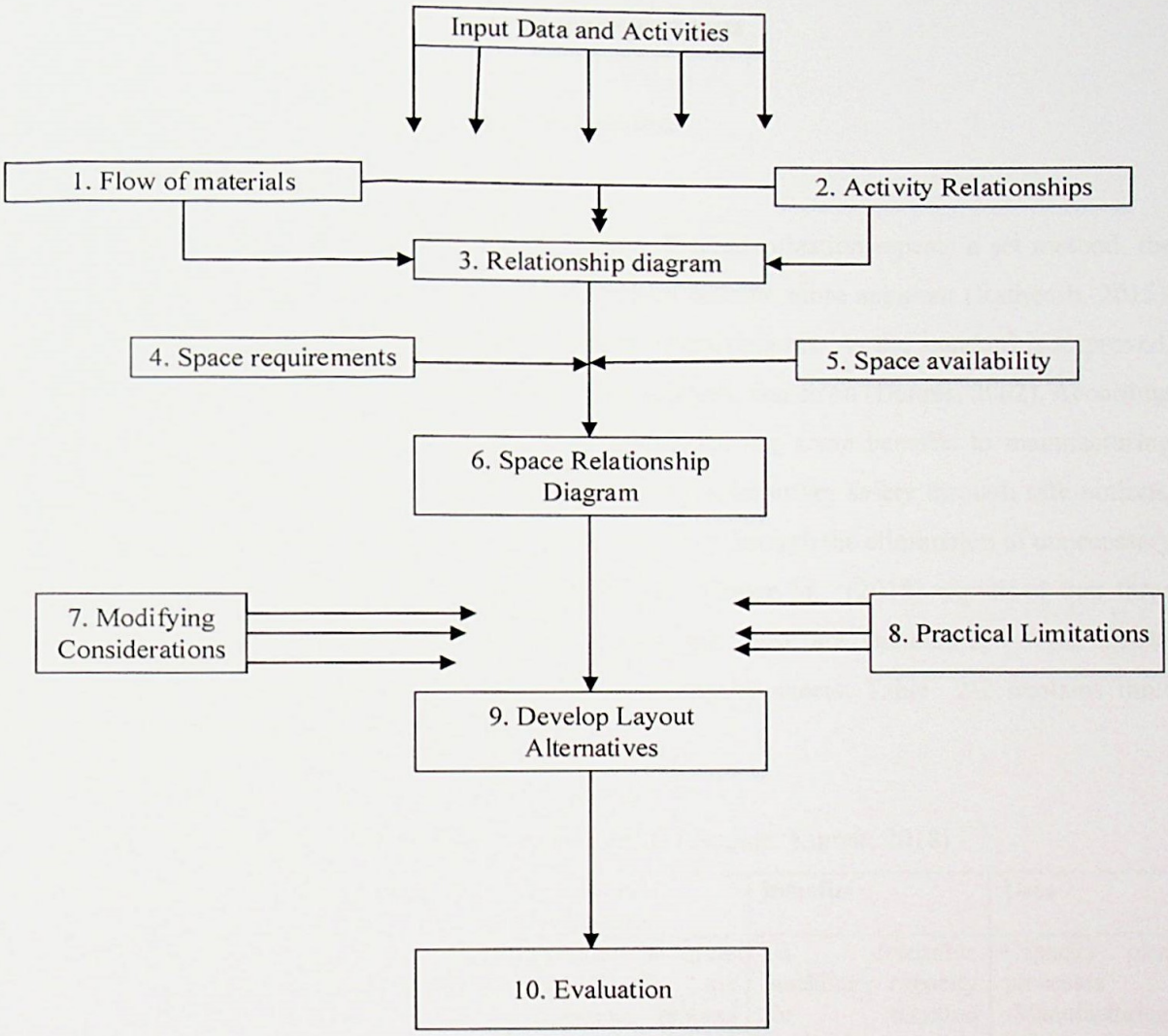


Figure 2-3: Muther's Systematic Layout Planning

This reveals the importance of two departments or units being close to one another in the final layout. The relationship diagram is then developed from the information. The space availability and requirements are then analyzed for each activity and then assigned. The result of the analysis and assignment is building up a space relationship diagram (Tompkins, 1996). The design of the new layout alternatives precedes the space relationship. This considers constraints that should be modified for and some practical limitations. The design alternatives are then evaluated to pick the best fit layout.

(Kulkami, B, & H.M, 2015), outlined the following general objectives for facility layout design:

i. Minimum space costs, handling and re-arrangement costs
ii. Minimum backtracking and bypassing
iii. Minimum traffic congestion and shape irregularities

2.5.6 Work standardization

It is one of the most powerful but least used tools. Work standardization repeats a set method, the process is more organized and improvement opportunities become more apparent (Ratheesh, 2015). Work standardization forms the baseline for continuous improvements. As the standard is improved, the new standard becomes the baseline for further improvements, and so on (Dennis, 2002). According to (Ahme, Brunsson, & Tamm , 2007), work standardization has some benefits to manufacturing industries. The author further noted that work standardization improves safety through safe notions, helps quality through repeatable processes, increases efficiency through the elimination of unnecessary steps, and forms a baseline for continuous improvement. Kumar M. (2018) explained that three documents are used for developing standardized work and these are standardized work charts, standardized work combination tables, and production capacity sheets. Table 2-2 explains three documentation approaches and how they are used.

Table 2-2: Standardized work methods (Source: Kumar, 2018)

Type of document	**Explanation**	**Procedural description**	**Benefits**	**Uses**
Production capacity sheet	Indicates the capacity of machinery in the process	Consider the cycle time of the equipment, process lead time planned and changeover times	To determine machinery capacity for required production	Capacity planning processes -Manufacturing industry
Standardized combination	Indicates the relationship between two or more activities that occur simultaneously	Considers manual and automatic equipment operations	Makes simultaneous work to be analyzed easily and quickly	Two simultaneous operations and automatic welding robot
Standardized work chart	Indicates operator movement and material location relationships	Record, determine improvements, evaluate and document the sequence of the job	Eliminate waste, creates a balanced flow of operations and it is a base for continuous improvement through Kaizen	All operations

2.5.7 Waste management and Utilization

The beef industry expands greatly as the demand for high-quality beef increases in both local and export markets. At the same time, industry and the public become more conscious of animal welfare, the environment, and workplace health and safety. This includes management of the main wastes of the feedlot, namely manure, and effluent (Tucker, Mcdonald, O'Keefe, Craddock, & Galloway, 2015). According to (Iowa State University, 2002), types of wastes associated with beef abattoirs are solid waste which include dung and urine, odor, dust, flies, liquid waste, effluent, and manure. This waste needs to be utilized in a proper manner such as cleaning of drains and sedimentation tanks and basins, effluent irrigation and systematically monitoring fly populations (Tucker, Davis, Sccobie, Trigger, & Poad, 2010).

Table 2-3: Ground wastewater / Sanitation Technologies and their application

Groundwater vulnerability	**Premises with an Individual water Connection**	**Premises without an Individual Water connection**
High	➢ Waterborne sewers + wastewater treatment ➢ Septic tanks + small bore sewers + wastewater treatment	➢ Sealed VIDP latrines ➢ Sealed dry composting latrines
Low	➢ Waterborne sewers + wastewater treatment ➢ Septic tanks	➢ Single pit VIP latrines ➢ VIDP latrines ➢ Sealed dry composting latrines

According to Richards (2005), adequate provision of wastewater and sanitation has lagged, and the author further stated that Botswana is a semi-arid country with a scarce water resource. Moreover, these resources particularly groundwater, are at a risk because of pollution arising from the use of septic tanks and un-lined pit latrines, and the use of unlined waste stabilization ponds. Surface waters are also at risk from the unsatisfactory quality of effluent discharges arising from the overloaded or inadequately maintained plants. Institutional, financial and technical responsibilities within the wastewater/ sanitation sector at present are fragmented, resulting in uncoordinated planning, design, and implementation as well as unsatisfactory operation and maintenance (Richards, 2005).

The author further states that with pollution of the country's water resources already occurring and the volume of wastewater expected to increase 2.5 times by the year 2020, therefore the government has recognized the need to develop a comprehensive National Wastewater/ Sanitation Management Policy to prevent the situation worsening. Table 2-2 illustrates the groundwater vulnerability wastewater/sanitation technology choices and their applications depending on the level of water supply service and groundwater vulnerability (Richards, 2005).

2.5.8 Work-Study and Time study

Work-study focuses on how a task can be accomplished. Time study and method study combined make up work-study (Chary, 2009). Time study procedure involves the timing of a sample of worker's performance and using it to set a standard (Heizer, 2000). The technique used to analyze results for motion study is the basic MOST general move sequence, which consists of five-step patterns shown in Figure 2-4. MOST index measures and analyzes work by concentrating on the movement of the objects.

Motion Study

According to (Chary, 2009), motion study is a technique of analyzing the body motions employed in doing a task to eliminate or reduce ineffective movements and facilitates effective movements. By using motion study and the principles of motion economy the task is redesigned to be more effective and less time-consuming. Gilbreths pioneered the study of manual motions and developed basic laws of motion economy that are still relevant today. They were also responsible for the development of detailed motion picture studies, termed as Micro Motion Studies, which are extremely useful for analyzing highly repetitive manual operations. With the improvement in technology, of course, a video camera has replaced the traditional motion picture film camera. Motion study encompasses micromotion study, and both have the same objective: job simplification so that it is less fatiguing and less time-consuming. While motion study involves a simple visual analysis, a micro-motion study uses more expensive equipment (Chary, 2009). The two types of studies may be compared to viewing a task under a magnifying glass versus viewing the same under a microscope. According to Patil e.t.al (2017), Maynard Operation Sequence Technique (MOST) system measures and analyzes work. Three activity sequence models were motion aggregated, which are;

- General move. This sequence model is used when an object is moved freely through space from one location to the next (e.g., picking something up from the floor and placing it on a table)

- Controlled move. This sequence model is used when an object is moved while it remains in contact with a surface (e.g., sliding the object along the surface or moving a lever on a machine)
- Tool use. This sequence model applies to the use of a hand tool (scissor, tape measure, or tailor's chalk).

Basic MOST® WORK MEASUREMENT TECHNIQUE		
ACTIVITY	SEQUENCE MODEL	SUB – ACTIVITIES
General Move	A B G A B P A	A – Action Distance
		B – Body Motion
		G – Gain Control
		P – Placement
Controlled Move	A B G M X I A	M – Move Controlled
		X – Process Time
		I – Alignment
Tool Use	A B G A B P _ A B P A	F – Fasten
		L – Loosen
		C – Cut
		S – Surface Treat
		M – Measure
		R – Record
		T - Think

Figure 2-4: Basic Maynard Operation Sequence Technique (Source: Chary, 2009)

A further explanation for the activities is shown in Table 2-4.

a. General Move

The general move involves action distance represented by A, body motion represented by B, gain control represented by G, placement represented by P. Action distance parameter is used to describe movements of the fingers, hands, or feet (e.g., walking). The movement can be done when loading or unloading. Body motion parameter defines vertical body motions and actions (e.g., sitting, standing up). The gain control parameter is used for any manual actions involving the fingers, hands, or feet to gain physical control of one or more objects. It is closely related to the grasp motion element in MTM (e.g., grasp the object). The placement parameter is used to describe the activities involved to lay aside, position, orient, or align an object after it has been moved to the new location e.g., position the object. Raj e.t al (2017) stated that parameters occur in the below standard sequence general move.

Table 2-4: MOST parameters (Source: Chang et.al., 2013)

A	B	G	A	B	P	A
Action distance	Body motion	Grasp	Action distance	Body motion	Placement	Action distance

The first three parameters (A B G) in Table 2-4 represent basic motions to get an object, the next three parameters (A B P) represent motions to put or move the object to a new location, and the final parameter (A) applies to any motions at the end of the sequence, such as return to the original position. To complete the activity sequence model, each parameter is assigned a numerical value in the form of a subscript or index number that represents the time to accomplish that action.

b. Controlled move

The first parameters (A B G) represent to get an object, the next three parameters (M X I) represent motion to move or actuate, and (A) represent motion to return.

c. Tool use

ABG ABP _ ABP A, in which ABG represents motion to get the tool, ABP represents a motion to put the tool, (_) represent motion to use the tool, ABP represents motion to put aside the tool, and A represent motion to return.

The procedure of basic MOST method

In general, nine steps are used for applying basic MOST methods, according to Kumar (2010) which are;

i. Selection of Job
ii. Select the Operator for study
iii. Record details of activity and conditions of Work
iv. Observation of each parameter Phases
v. Parameter Indexing
vi. Addition of all the parameter Index values of activity
vii. Convert the total of Index values into time measurement unit (TMU)
viii. Convert the TMU value in corresponding time (Hours)
ix. Convert the time from an hour into Minutes (Kumar, 2010)

The operator 's activity time (in seconds) is calculated by adding the index values and then multiplying the sum by 0.036 sec (1 TMU =0.036 sec). The scale used is as follows; 1 T.M.U = 28 of a second;

STOPWATCH TECHNIQUE

Stopwatch time study measures how long it takes an average worker to complete a task at a normal pace.). A "normal" operator is defined as a qualified, thoroughly experienced operator who is working under conditions as they customarily prevail at the workstation, at a pace that is neither fast nor slow, but representative of an average. The actual time taken by the above-average operation must be

increased, and the time taken by the below-average must be reduced to the value representative of normal performance. Performance rating is a technique for equitably determining the time required to perform a task by the normal operator after the observed values of the operation under study have been recorded (Nakayama, 2002).

Method study symbols for recording results

Recoding facts on method study was originated by Gilbreth as a way of simplifying and making sure that the presentation of the facts is clear without ambiguity (Rathod, Jadhav, & Babar, 2016). Rathod, Jadhav & Babar (2016) further stated that it is very important to use symbols instead of the written description as it enables us to grasp them quickly and clearly. Below in Figure 2-6 shows a list of various symbols used for recording the facts.

Moreover, in Figure 2-5 is a five basic method study symbols. These include:

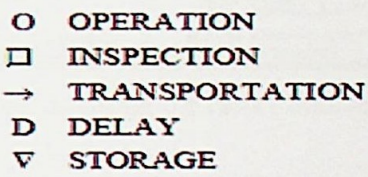


Figure 2-5: Method study symbols (Source: Ergonomics, 2016)

Figure 2-6 illustrates method study symbols that are considered in motion analysis and their explanation is defined below. The key five basic study symbols are further explored by Rathod et.al. (2016).

Operation: It entails when an object is added value or changed from one stage ahead towards completion. It includes the main steps involved in a process, method, or procedures. Some examples of operations are lifting, loading, offloading, and getting instructions from the supervisor.

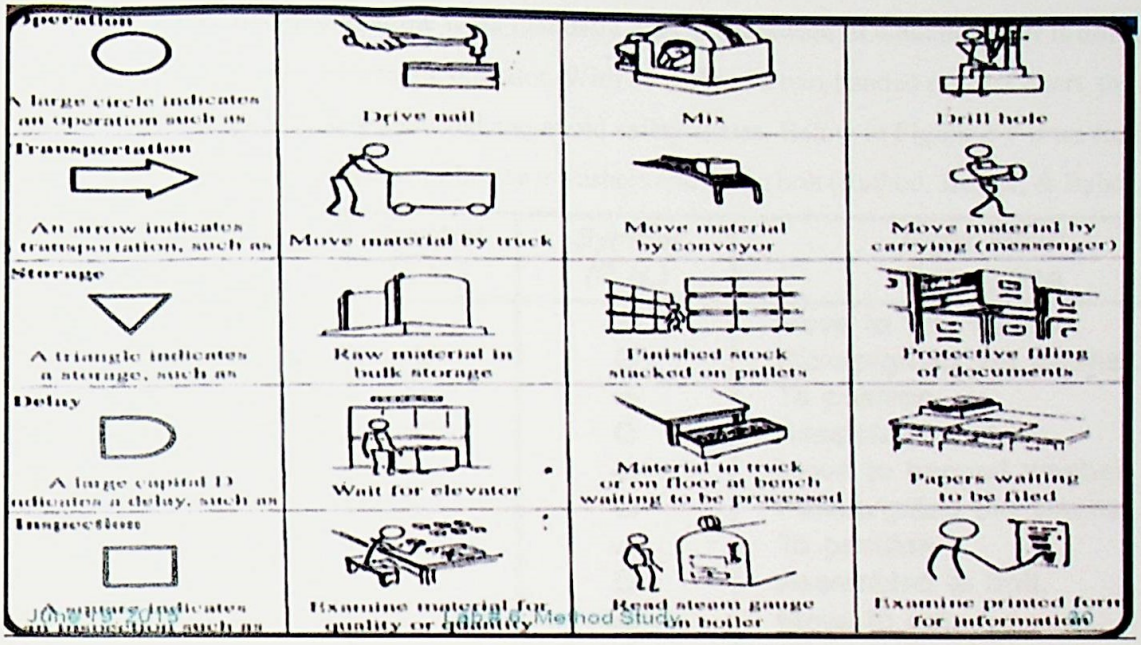


Figure 2-6: Method study symbols for recording the facts (Source: Rathod et.al., 2016)

Inspection: This is when an object is critically examined and compared with the standard quality or quantity. Some examples of inspection are visual observation for the finish, quantity counting of incoming material, and outgoing finished product.

Transportation: This is the movement of workers, materials, or equipment from one place to another. Some examples of transportation are the movement of materials from one station to another and workers traveling to bring tools.

Delay: This is when the immediate performance of the next planned process/ activity does not take place. Some example of delay is work waiting between consecutive operations, workers waiting at tools area and plant operators waiting for instructions from supervisor

Storage: This is when the object or material is retained for reference purposes or controlled storage that is issued in some form of authorization. Some examples of storage are the raw material in bulk storage, finished stock stacked on pallets, and protective filing of documents.

Two-handed process charts

A two-handed process chart shows the movement of each hand in a manual process (Rathod, Jadhav, & Babar, 2016). It is used when analyzing a manual assembly process, to make it easier to perform.

Usually, when the operator does the work manually, they are unaware of what the other is doing which may end up leading to injuries to the operator. With the help of a two-handed process chart, the motion between both can be precisely analyzed and avoid safety issues. Below in Figure 2-7 is an example of a two-handed process chart in assembling two washers and nut to bolt (Rathod, Jadhav, & Babar, 2016).

Left Hand Description	Symbol (L.H.)	Symbol (R.H.)	Right Hand Description
1 Move to bolt	⇒	⇒	Move to first washer.
2. Grasp the bolt	O	O	Pickup/grasp the washer.
3. Move to position	⇒	⇒	To position
4. Hold	∇	O	Assembled to bolt.
5.		⇒	Move to second washer.
6.		O	Pickup/grasp the washer.
7.		⇒	To position
8.		O	Assembled to bolt.
9.		⇒	Move to nut.
10.		O	Pick up the nut.
11. Move to box	⇒	⇒	To position.
12. Aside to box	O	O	Assembled to bolt

Figure 2-7: Two-handed process chart (Source: Rathod et.al., 2016)

SIMO Chart (Simultaneous Motion Chart)

Zandin & Maynard (2005) defined a SIMO chart as a micro-motion study invented by Gilbreth to present graphically the separable steps of each pertinent limb of the operator under study. Moreover, it is an extended version of the two-handed process chart and gives substantially detailed left and right-hand operation chart. SIMO chart records different therbligs performed by different parts of the operator's body on a common time of scale at the same time.

Therbligs

Zandin & Maynard (2005) stated that when analyzing the result of several motion studies conducted, Gilbreths concluded that any work can be done by using a combination of some or all of 17 basic motions, called Therbligs (Gilbreth spelled backward). These can be classified as effective therbligs and ineffective therbligs. Effective therbligs take the work progress towards completion. Attempts can be made to shorten them, but they cannot be eliminated. Ineffective therbligs do not advance the progress of work and therefore attempts should be made to eliminate them by applying the Principles

of Motion Economy. Below in Figure 2-8 shows therbligs that are used in Industrial Engineering along with their symbols and description;



Figure 2-8: Therbligs used in Industrial Engineering (Souce: Ergonomics, 2016).

Frank and Lillian Gilbreth used motion picture to study worker motions, and they devised eighteen motions known as therbligs that describes all possible work. Table 2-5 shows abbreviations that are used in therbligs and their meanings. Mehta & Desai (2014) stated that therbligs are a diagrammatic representation of movements such as search, select, symbols, and alphabets for recording purposes.
A SIMO chart is very beneficial since it allows a very precise and detailed analysis of the operation. The work cycle from the recorded film can be extensively studied away from the disturbing surrounding of the actual workshop flow or workstation. Furthermore, Rathod et.al (2016) suggested that the SIMO chart is examined with caution to attain complete detail with a complete cycle and helps in drafting a better combination of the desired motions. Mehta & Desai (2014) further stated that the goal of motion study is to improve planning and scheduling cost and for safety. Moveover Ergonomics (2016) suggested that motion study working conditions include; temperature and humidity, ventilation, illumination (lighting or light), color, noise and vibration, work breaks, safety, causes of injuries and accidents, office decorations and layout, equipment safety -desks, chairs, computers, telephones, chainsaws, ladders, drills and whatever equipment that is used to run the business.

Table 2-5: Therbligs abbreviation and its meanings

Therblig Name	Symbol
Search	S
Find	F
Select	SE
Grasp	G
Hold	H
Transport Loaded	TL
Transport Empty	TE
Position	P
Assemble	A
Use	U
Disassemble	DA
Inspect	I
Preposition	PP
Release Load	RL
Unavoidable Delay	UD
Avoidable Delay	AD
Plan	PL
Rest	R

Chang & Park (2013) stated that ergonomic equipment and safety plays a very important role in running day to day activities of a business. Moreover, proper equipment and safety regulations help increase productivity and efficiency by reducing injuries. Table 2-6 below shows how a beast is stunned in an abattoir using a two hand-process chart with the help of therbligs.

Table 2-6: Two hand process chart of an operator stunning a beast (refer to Table 2.5 for therbligs symbols)

Sequence number (S. No)	Left-hand description	Therbligs	Time (in seconds)	Right-hand description	Therblig	Time (in seconds)
1	Search and picking the stunning gun	S, H	23	Search and picking the stunning gun	S, H	23
2				Load the gun with a bullet	U	24
3	Removing the cap used to secure bullets for the stunning gun	P	60			
4	Close the cap	UP	34	Hold the stunning gun steadily and provide support	H, P, U	34
5.	Lift the stunning gun	P	23	Lift the stunning gun	P	25
6.	Hold the bottom end	P	10	Hold the top end close to the loaded head cap	P	10
7.	Points the head and hit the head of the beast	GUP	23	Points the head and hit the head of the beast	GUP	23

2.5.9 Lean Manufacturing, Practices, Philosophies and Lean Sigma Methodologies Applied in Abattoirs

Lean manufacturing has just made its introduction in the world of research in beef abattoirs, even though lean management has been studied for decades (Limere & Manoj, 2016). However, some case study-based papers have been published by different authors to show the implementation of lean tools

in agriculture and beef sectors. A study in the UK Red Meat showed an augmentation of profitability through the whole value chain (Limere & Manoj, 2016). Zokaei & Simons (2006) explained that the implementation of lean practices, particularly standard operations and Takt time has the significant potential to increase profits, productivity, and cost savings for the farmers. Colgan, Adam & Topolansky (2013) performed a case study on the benefits of implementation of lean thinking in farms in the United Kingdom. Lean thinking tools that were used are Five Principles of Lean, VSM, and the Seven Wastes Theory which resulted in an increase in competitiveness by reducing waste and improvement of the food quality.

Furthermore, case study results of Colgan, Adam & Topolansky (2013), Value Stream Maps indicate that there is a possibility for lean improvements concentrated on dynamic markets outlets, more efficient utilization, and allocation of fixed cost resources to add value. The author further stated that there is also challenges in applying lean manufacturing in abattoirs especially when measuring the financial value that is being added by a lean implementation. Moreover, the author suggested that managers and staff members must be aware of the five principles of lean through training to help in the success of a lean application.

Simons & Taylor (2007) focused on the value chain involving the red meat industry. These authors yielded a substantial improvement in vertical collaboration (Simons & Taylor, 2006). This is a consumer value and supply chain analysis method based on tools and techniques from the lean paradigm. A current State Map and key performance characteristics were developed of the whole chain. The results showed that supply time was 185 hours and from these 185 hours, only 1.4 hours was value-adding time (Simons & Taylor, 2006).

Andersson & Eklund (2012) stated that applying lean practices and principles in agriculture lead to a more structured and less stressful work environment. Dyrendahl & Granath (2011) specified that the basic principle of lean reduces wasteful activities and losses for the organization. Food Chain Center at Cardiff Business School showed how wasteful activities and costing activities could be determined in the fresh produce industry. The authors discovered that more than 95% of the time; inactive time is between harvesting and consumer purchase. That is where the product is either waiting or involved in steps that are non-value adding and they provided remedial solutions to those problems. Voulgarakis et.al. (2013) stated that VSM analysis is an effective tool to identify waste in the agro-food supply

chain. According to Radnor (2010), lean must not be a strategy but a philosophy which emphasizes long-term goal and continuous improvement. Bowen & Youngdahl (2009) pinpointed that implementing lean manufacturing in an abattoir is a good thing but it brings a lot of changes in the culture and the environment and thus communication is vital for lean implementation. Below in Table 2-7 illustrates regions that implemented lean tools in abattoirs.

Table 2-7: Literature sources of lean implementation in abattoirs

Lean tools implemented	**Type of Industry**	**Place of implementation**
i. Supply Chain Management ii. Value Stream Mapping	Beef Industry	UK Red Meat
i. Five principles of lean ii. Value Stream Mapping iii. Seven wastes Theory	Farms	United Kingdom

2.5.10 Beef slaughter process

International Meat and Poultry HACCP Alliance (1996) stated that developing and verifying a flow diagram for the production of a certain product is very important. Furthermore, flow diagrams provide a clear, simple description of the steps in the process which are precisely under the control of the facility. Figure 2-9 shows a generic flow diagram for beef slaughter:

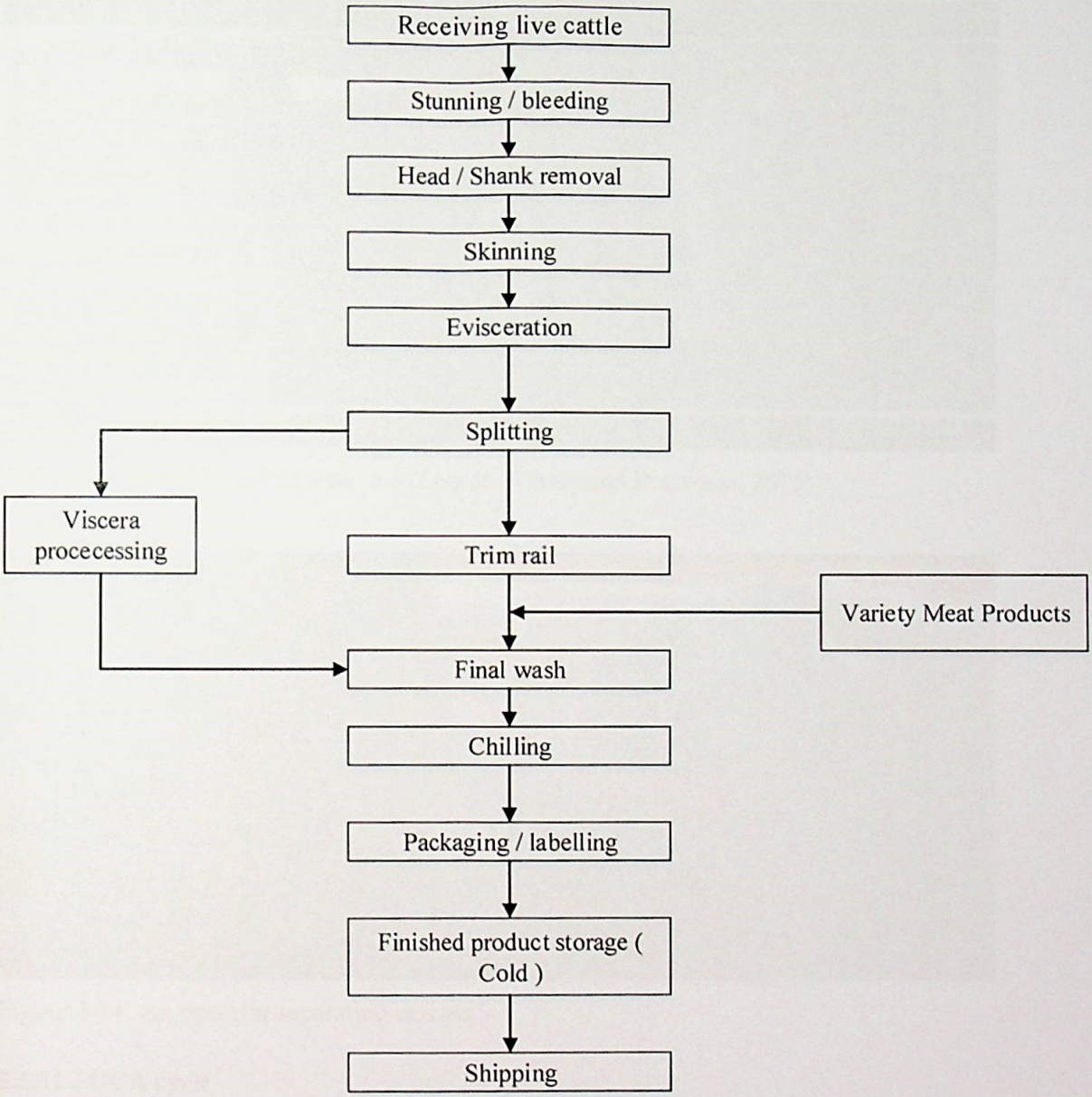


Figure 2-9: Generic process flow in a beef abattoir (Source: International Meat and Poultry HACCP Alliance, 1996)

Botswana Private Abattoir products

The company serves individuals and local farmers by slaughtering their beast at a reasonable fair price. Its products are carcass, hides, and skins. Below in Figure 2-10 and Figure 2-11 are images of the company's products.

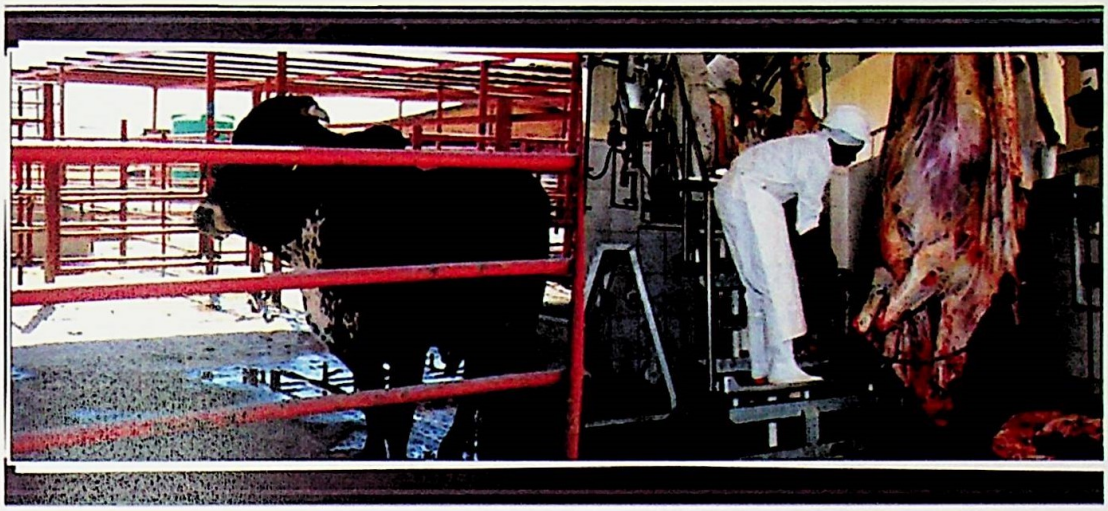


Figure 2-10: Live beast and a carcass (Source: Silverwind Botswana, 2015)



Figure 2-11: An operator separating carcass

2.5.11 PDCA cycle

It is also known as a Deming cycle. Charantimath (2006) defined the PDCA cycle as a problem-solving process adopted by firms engaged in continuous improvement. Moreover, Shewhart (2012) explained that before continuous improvement process begins; testing function needs to be performed, gathering planning steps to understand the development project objectives, current status, project plans, function specification, and risks. Once these plans have been finalized, it is implemented (Liker & Franz, 2011). Furthermore, the author explained that the implementation is also checked for anticipated improvement. When the experiment is successful, a final action such as methodological standardization is put in

practice to ensure that new methods will be continuously sustained for improvement. Charantimath (2006) supported other author's publications by emphasizing the entire focus is on the problem rather than remedies. Furthermore, Keith (2015) explained that the PDCA framework has four steps which are critical to ensure the achievement of the project objectives, and this framework is shown in Figure 2-12.

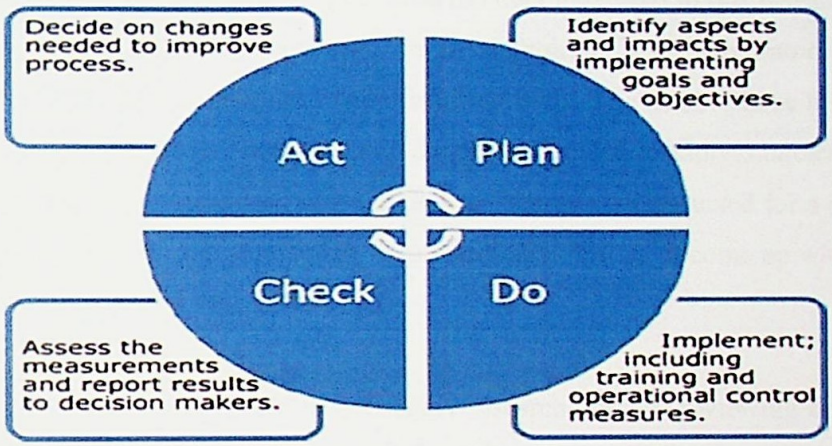


Figure 2-12: PDCA model (Source: Keith, 2015)

2.5.12 Define-Measure-Analyze-Improve-Control (DMAIC) technique

DMAIC is an abbreviation of the five improvement steps comprising of Define, Measure, Analyze, Improve, and Control (McAdam & Lafferty, 2004). Moreover, the method is often described as an approach to problem-solving. DMAIC is a data-driven improvement cycle used for improving, optimizing, and stabilizing business processes and designs (Das & Gopinadhan, 2016). McAdam & Lafferty (2004) stated that the DMAIC method is consistent with the problem-solving steps of the PDCA model and places more emphasis on integrating specific tools into each step of the method.

2.6 Chapter conclusion

Literature review outlined sources, materials, publications, case study reports, documents, and books that reveal the successful implementation of lean manufacturing tools and techniques, gaps that exist in the implementation of lean tools in abattoirs, and try to close those gaps by emphasizing them through writing. This chapter summaries literature sources of various authors on issues surrounding lean manufacturing tools, productivity, process improvements, waste management, 5S, efficiency, and Kaizen in a beef abattoir.

Chapter 3 : Methodology

3.0 Introduction

Based on the research questions and the nature of the circumstance in question, a case study design was chosen. A case study was investigated to be the baseline for this research because the lean implementation in abattoirs is difficult to apply. The methodology used in this research is exploring a conceptual framework of lean implementation in an abattoir. It is an exploratory research which explores process improvements using lean manufacturing tools. The author chose to conduct it as an exploratory because problems were not clear, and the author decided to address unclear issues through a case study. Stebbins (2001) explained that exploratory research is conducted for a problem that has not been studied more clearly and its mandate is to establish priorities to come up with an operational definition and improve the final research design.

The methodology of this research relied on secondary research (such as reviewing available literature and data), informal qualitative approaches (such as discussions, consultative meetings), and formal qualitative research (such as face to face interviews, direct observation, case studies, audits and plant tours). Lean tools were first introduced at the abattoir through campaigns, proposals to company's management to establish management's buy-in, employee training, and awareness. After it was introduced it was then agreed to map the strategies on how it is going to be implemented with an agreement with the abattoir's management. A qualitative method was used to conduct the case study and it is explained in the next paragraph. In designing the questionnaire, a Likert scale was used to scale responses in the questionnaire survey. A five-point scale was used to allow individuals how much they agree or disagree with a statement. The design of the survey question is based on this standardized scale of Likert. Two-line managers, three-line supervisors, and twenty-six operators were the subject of the study because they are the sources of relevant data through surveys and interviews.

3.1 Qualitative Approach

The qualitative approach of gathering data focuses on describing a phenomenon in a deep comprehensive manner. In this research, data were collected using both structured and unstructured interviews and open-ended questionnaires. Likert scale was used in designing the interview questions and survey questionnaires. Access to the company documents was granted to the researcher to have a look at the available production analysis and company policies. Some of the advantages of using this

method are that it is more subjective, that is, describes a problem or condition from the point of view of those experiencing it, provides verbal information that may sometimes be converted to numerical form, and may reveal information that would not be identified through pre-determined survey questions. Below explains methods and instrumentation that were used in each objective.

i. To identify the existing process, analyze and optimize it using lean manufacturing tools to achieve process efficiency and workplace organization

This objective wanted to find out inefficiencies that occur within production/ business operations. The descriptive research design was used to gather information about the present existing conditions needed. For this objective qualitative research was used to gather data on the current production and business process. The work method which comprises of time measurement and method study were used to measure time activities among the process flow so that the researcher can get the existing/ current process turnaround times. The study population of thirty-one people were involved. Twenty-six Operators, three-line supervisors, and two top managers were chosen to be the source of relevant data. Below in Table 3-1 shows the list of participants and how they were categorized. See Appendix A for sample interview questions used. One person from top management (production manager) was the main respondent of the study since he is in charge of monitoring product delivery time and customer satisfaction ratings. Line supervisors and operators who are directly involved in the production and operation, meat inspectors in each process were interviewed and observed to gather important information. Self-constructed interview questions see Appendix A, standardized forms such as time study sheet see Appendix I, observation form, process flow chart, two-handed process chart, 5S's audit checklist, waste identification form, and 5S's training manual were the main instrument for data collection. The interview is a conversational practice where knowledge is produced through the interaction between an interviewer and an interviewee (Bloom, Barbara, Crabtree, & Benjamin, 2006).

Face-to-face interviews were also used as an instrument to collect data. Participants for face to face interview were the production manager and director, two-line supervisors and 7 Operators. The questionnaire, see Appendix B, was used to investigate the inefficiencies that the abattoir experiences in its operation processes. At first, questions were prepared. Those questions prepared were then distributed and asked the participants to complete at their convenience. The purpose of this research was then explained to all participants. The researcher made sure that all the questions are understood by the participants in the same way. Answers from the participants were then written down in a standardized form. Some of the benefits of using this method

include; easy correction of mistakes or misunderstandings that may arise during the survey study, this is possible because of the face to face interaction. Moreover, interviews are timesaving since the researcher gets first-hand information immediately from the participants, that is, there is no significant time delay between question and answer. Interviews allow enough information to be collected hence allows the interviewer to get the information they need for research. The List of interview participants is shown in Figure 3-1. A two-handed process chart was used to capture process flow from beginning to end. Moreover, in capturing the production and business process, a list of activities was captured as they are the ones that add up to a process for an end to end value-adding (as-is process). A time study sheet was used to capture process times of activities in a process. Waste identification was used during 5S's pre-audit and 5S implementation. 5S training manual was used during 5S training awareness with all employees by the 5S steering team.

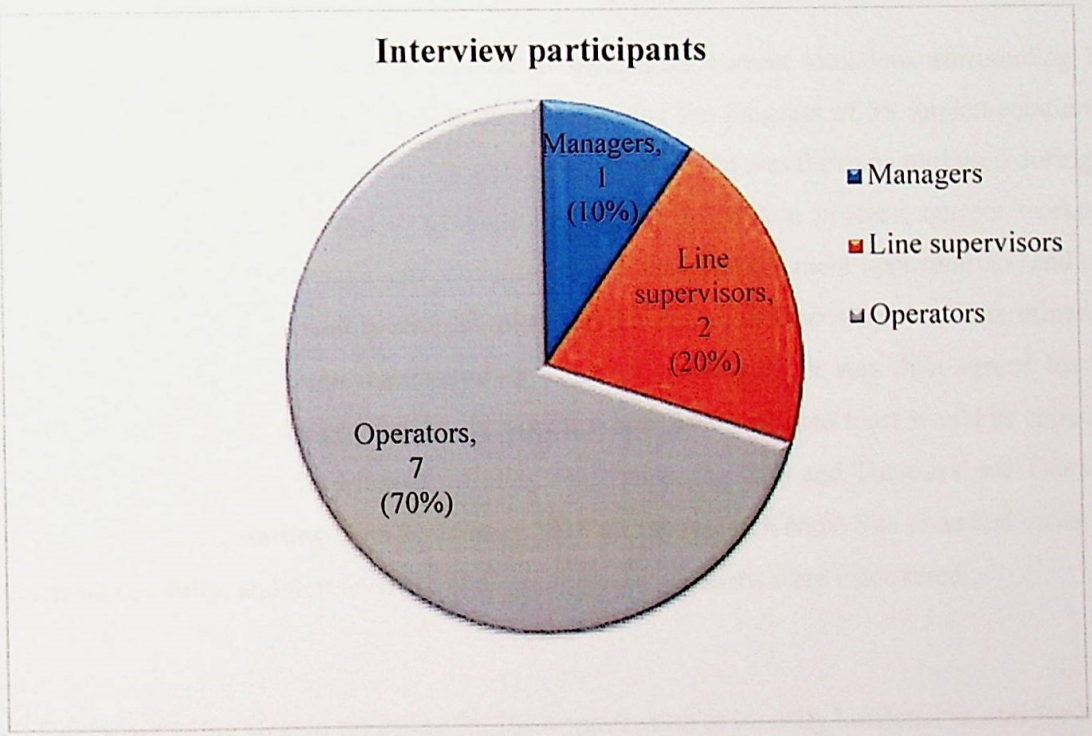


Figure 3-1: Face to face interview participants

Table 3-1: List of participants

Occupation		Number of participants
Top management (executive managers)		1
Middle management (line supervisors)		2
Operators	Semi- skilled	2
	Skilled	3
	Unskilled	2

A sample questionnaire is shown in Table 3-2 below. Figure 3-1 shows interview participants with the guidance of the prepared question, see Appendix A. Only the production manager, one-line supervisor, and seven operators responded to the questionnaire.

Site visits and Audits

Site visits and audits were used as a method to investigate current situations surrounding lean implementation. Site visits were a formal way of monitoring the progress of 5S implementation. 5S Pre- audits were conducted to find the status quo. Direct observation was the main tool used during site visits. Direct observation was used to evaluate the current production process, current workplace organization, current waste management practices, current lean improvement opportunities, and other physical outcomes that can be readily seen. Through this method, scope/focus area was determined (i.e. which areas are needed for lean manufacturing tools in an abattoir). It was then agreed between researcher's supervisor and the production manager that site visits and plant tours would be conducted three days in a week, that is on Mondays (during cattle receiving day) and Tuesdays and Thursdays (during slaughter days), starting from 21 January 2018 till the research ends. Site tours and visits were conducted successfully, and that is where opportunities and problems were discovered.

ii. Carry out value stream mapping for the organization to identify bottlenecks and for better work methods and cycle time improvements

For this objective, the researcher wanted to find out bottlenecks and excess capacity that the case study company experiences. A questionnaire see Appendix B, consultative meetings, and interviews were

used as methods of collecting data. Table 3-1 shows a list of participants for the survey study. Supporting questions in Table 3-2 were also used to investigate the existing bottlenecks in the abattoir's value stream. Th current value stream status of the case study company was gathered to establish the existing value stream map. As a way of understanding the abattoir's value stream, consultative meetings were also used as an approach to know the abattoir's value chain, to draw a snapshot of production flow, understanding actual production flow with all its cycle times and identification of potential improvements. Important information was gathered from line supervisors, Operators who are directly involved in the production and operation, operators, and meat inspectors in each operation activity. Self-constructed interview questions, observation forms, and process flow charts were the main instrument for data collection. Interview questions prepared, see Appendix A, and a sample interviewed people are shown in Figure 3-1 was used to investigate abattoir's value chain, in terms of material flow and information flow. Time study sheet was used to capture turn-around times for these activities, in terms of value-adding and duration of activities. A process flow chart was used to depict a visual representation of the existing current value stream map to identify waste and bottlenecks.

iii. To develop a framework for lean implementation in a beef abattoir

This objective was to develop a framework for lean implementation in a beef abattoir, since there was little information on lean implementation in a beef industry during literature reviews and document analysis. Literature sources and lean expert interviews were chosen to be the source of relevant data. Important information on the development of a lean implementation framework in a beef industry was found through reading books on lean implementation in a meat processing industry and agriculture, strategy framework formulation books by different authors, and consultation with lean experts. A survey questionnaire was given to two lean expert who were suggested by the abattoir's production manager. These two lean experts that were consulted are from Botswana's national abattoir (BMC) and the other one is from the private beef processing industry (Senn foods). The sample questionnaire used is shown below in Table 3-2.

Table 3-2: Sample questionnaire for participants

Questions	Answers				
	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
Do leaders of the company know what lean is?					
Do you have a lean expert consultant, who helps to promote the sustainable continuous operation					
Does the company's culture cater to continuous improvement					
Does the company experience challenge in its production					
Are you aware of any framework that the abattoir uses to improve production sustainability					
Is the abattoir's strategy aligned with the abattoir's goal					
Do you know the abattoirs strategy framework					
Do you know the abattoir's goals, vision, and mission?					
Is it possible to develop a framework for lean implementation in beef abattoirs					
Will the abattoir provide enough input to help develop lean implementation framework in beef abattoirs					
Does your lean consultant expert deal with external people for issues of continuous improvement					

3.2 Chapter conclusion

This chapter shows methods that were used to carry out the research, illustrations of company audits that were done with the help of 5S scoring sheet tool, face to face interviews, a questionnaire that was distributed as a way to understand and investigate how the current processes are performing in terms of 5S standards, workplace organization, process documentation, current process cycle time efficiency and current standard operation in the production line and workflows. It also illustrates tools that were used per each objective.

Chapter 4 : Implementation of lean tools

4.0 Introduction

The purpose of this research was to implement lean manufacturing in a private abattoir. To establish how well the literature matches the real-life issues; a framework for lean implementation was followed with the help of the PDCA problem-solving approach. PDCA was used for approaching implementation in this case study company. PDCA was selected because it helps to achieve continuous improvement in business process management. PDCA was chosen over other methodologies such as DMAIC because the Plan phase allows defining the problem, improvement activity, project goals, to understand SIPOC (Supplier-Input-Process-Output-Customer) value chain, current/ existing process performance, frequency of problems or causes, root cause analysis to uncover causes, identifying a possible product, service and process failures, understanding an overview of an entire process starting and finishing at the customer, and its analysis of what is required to meet customer needs.

The DO phase allows the implementation of corrective measures and sees countermeasures. Check and Act Phase allows improved and future process performance, documenting quality control plans, visual controls for 5S, and other controls that make it possible to detect errors and be predictable immediately. Another reason for choosing PDCA over DMAIC is that PDCA is a methodology that allows the implementation of practices at any level/ magnitude and helps to manage change effectively compared to DMAIC that depends mainly on huge data, for example, in the abattoir; during times of defining the issues the abattoir is facing there wasn't enough data to justify whether there are inefficiencies up until plant tour and interviews were used to investigate the problems that the abattoir faces.

Table 4-1 below illustrates how PDCA was merged to justify its choice over the DMAIC problem-solving approach (in terms of comparisons). Lean tools that were chosen to be implemented in the abattoir are Value Stream Mapping and process documentation, 5S, work-study (that includes Method study and Time study). This chapter presents results findings before lean manufacturing tools were implemented.

4.1 Illustrations before lean implementation

Some issues were discovered before lean manufacturing tools were implemented. These issues were identified through the use of structured and unstructured interviews, see Appendix A, and data

collection instruments which are company audits, plant tours, company documents reviews, and observation. The existing abattoir's process efficiency given by the production manager was 45% and the utilization was 50%. This information was based on records from November 2017 till March 2018. The line cycle time was 2700 seconds or 45 minutes per carcass.

Table 4-1: PDCA and DMAIC problem-solving approaches (Source: Najmi & Sidhu, 2019)

Methodology approach	Merged approach (DMAIC)	Explanations and scope
Plan	Define	Clarify and define the problem
	Measure	Break down the problem
		Set a target
	Analyze	Analyze the root cause
		Develop countermeasures
Do	Improve	Implementation and see countermeasures
Check	Control	Evaluate results & processes
Act		Standardize success

Plant tour conducted

Plant tour was conducted on the 31st January 2018 with the help of unstructured interviews, and the process was identified. The purpose of conducting a plant tour was to understand the company's operations. Opportunities discovered during the plant tour are illustrated in Table 4-2 below, with issues identified, its description, and the scope of the area of interest. This includes insufficient visual control in the plant, unclear flow of work, and the abattoir not meeting daily production of 70 cattle per day.

Table 4-2: Area of interest identified during a plant tour

Problems / Issues	**Description**	**Area of interest**
The general layout of the plant	The plant layout does not have enough visual to alert areas of danger to employees	The researcher is willing to work with team members to create posters, displays on the plant for safety and health awareness

Not meeting targets which lead to long manufacturing lead times	The company does not meet its targets during busy days and sometimes in normal days	The researcher is willing to find ways in production and processes can be improved to expedite production, document the abattoir's processes
Un-optimized processes	The company does not have a clear flow of work, which lead to unbalanced allocation of work	The researcher is willing to optimize the abattoir processes through the use of lean manufacturing tools, techniques and practices and to document those processes

Current existing process

Research Company's process was identified through a plant tour with the help of face to face interview. Interview questions see Appendix A and questionnaire, see Appendix B; A high process level paradigm was identified, also known as SIPOC (Supplier, Input, Process, Output, and Customer). This is shown in Table 4-3 below;

Table 4-3: SIPOC high-level entities

Supplier	**Input**	**Process**	**Output**	**Customers**
Farmers	Cattle of any size	Lairaging cattle in a kraal	Unprocessed beef	Butchers
Individuals	Machinery	Stunning	offal's	ABC (hides customer)
	Labor	Slaughtering and bleeding	Hides	Hotels
		Hanging		Chain stores
		Skinning		Company own butchers
		Splitting		
		Measles checking		
		Offal and hides separating		
		Weighing		
		Dispatching		

Process flow was identified to find opportunities, bottlenecks, and areas that can be of interest in line with the research title. Process flow was mapped to find inefficiencies, process steps such as two

authorization that are done within the production line. One is done by authorizing receipt of a carcass by the operator, and the second one is authorization done by the inspector to accept the receipt of the carcass. The authorization causes some delays and carcass mixture especially when the inspector receives carcass while engaged in the assigned work. From the process, which was identified during plant tours, cattle are lairage or housed in a kraal according to the kraal's capacity. In those kraals, the cattle are branded as a form of identification. The identified cattle are then taken to the stunning box where stunning is done. After the cattle have been stunned, halaal is done and a crane lifts it up in the production line. After it is left hanging it is skinned, then splitting is done in two halves. The measles checking is also done, and offal's and hides are separated accordingly. After the measles inspection is done, weighing follows, and then it is dispatched. Below in Figure 4-1 is a process that was captured and observed during the plant tour.

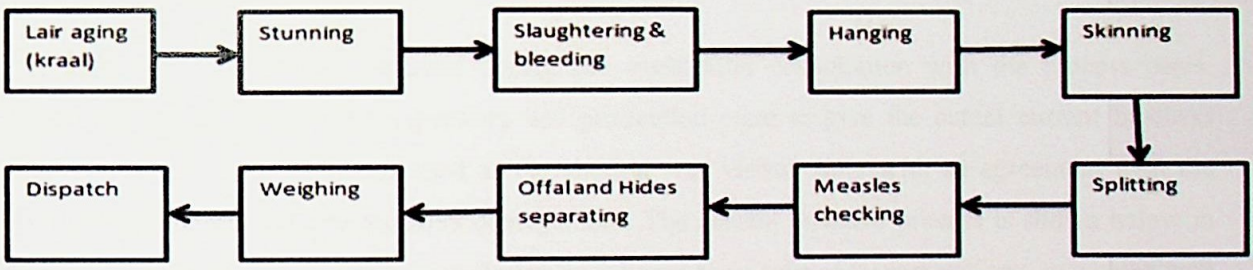


Figure 4-1: Process flow of Botswana Private Abattoir

Current value stream map

The current value stream map was identified through direct observation. From the interview answers, the current value stream shows that the production lead time is 47 cattle in 9 hours. Microsoft Visio was used to map the current value stream map with the help of a time study conducted. Current state map was created using Microsoft Visio for visual presentation. The current value stream map is shown in Figure 4-3. From the observation and interviews within the process, it was found out that there is high absenteeism due to operators complaining of back pains that they experience when they carry skinned head with their backs and this issue leads to the abattoir not meeting its target. It was also found out that there were unbalanced workloads of each operation, thereby the daily output of workers was not established. There was no specific assignment of operators to complete a particular task within the production operation. Other non-value activities identified when mapping the process are shown in Table 4-4.

Table 4-4: Non-value-adding activities

	People/workers	Machine	Material
Non value adding (NVA)	-waiting for machine	-set up time	-handling
	-waiting for product	-unscheduled maintenance	-moving
	-searching for tools		-transporting
	-unbalanced workload		-sorting
	-sorting condemned carcass		-inspecting
	-inspecting product		
	-fixing equipment		

Site Visits

Abattoirs process flow was mapped during site visits after consultation with the process users, production manager, and line supervisor and production team to give the actual current business process. Direct observation was used as the abattoir was visited daily with an agreement with the researcher's supervisors and abattoirs management. The current business process is shown below in Figure 4-2. The abattoir's production design is a linear form whereby workstations, machines, and equipment used are arranged in a line. The carcass and cattle are physically moved or manually moved though rails by workers using trolleys and hands. The production system is designed in such a way that a small amount of the total work is added along as the carcass is moved along the production line. It is also categorized by high production volume and low variety as of the abattoir is only cattle / small stock (usually goats) of any size. Farmers are the ones that bring their cattle or small stock in the abattoir and documents are checked at the receiving gate. These documents include verification from the Department of Veterinary Services, kgotla, and police officers. The company receives cattle a day before they are slaughtered and it's mandatory for them to spend a night before they are slaughtered. Receiving days are Mondays to Thursdays during weekdays from 0600 hours till 1900 hours. Stunning takes place from Tuesday to Friday from 0700 hours till 1600 hours operating nine hours (in one shift). If the cattle have all the requirements, it is allowed in the building, if it does not have all the necessary documents it is sent back to the owner at the owner's expense. Cattle are then offloaded, and lair aged in holding pens according to the company's holding capacity. Before there are lair aged there are branded for identification. This identification is helpful for the production manager to prepare the

killing agenda. The cattle are then inspected (ante mortem inspection), where they are checked for fitness. If the cattle are not fit, it is verified by the veterinary inspection to be stunned at the emergency stunning box. If the cattle are fit and fine, it is sent to the stunning box where it is slaughtered.

Halaal checking takes place after stunning, and then the slaughtered cattle are hoisted using a mechanized hoist machine. The carcass is hoisted above the ground, creating less chance of contamination of carcass by filth and blood on the blood. The platform is a system that operators use for movement. Upon hoisting, skinning of heads takes place and they are tagged systematically in a trolley where they will be inspected by meat inspect during production. Evisceration then takes place where the offals are separated and removed. Postmortem inspection takes place offal's are separated and done by a meat inspector and veterinary officer. A report is made after the postmortem inspection has been done and it is awarded by a veterinary specialist inspect. In that report, the veterinary specialist verifies whether the carcass and its offals are good for human consumption. If there are not good for human consumption, the products are either detained in a chiller for some days or they are thrown away. If the report states that the carcass and its products are good for human consumption it is passed along the production system. All documents are then checked which includes a report by an inspector. If all documents are fine, an establishment stamp is issued. The carcass is weighed, loaded, invoiced, and delivered to the end user. Furthermore, activities in the plant are categorized into three sections which are gate receiving section, lair aging and the production shop floor.

Gate receiving section

In this department, cattle are received, and all the documents about the cattle are checked and inspected. Cattle permits, a letter from kgotla or affidavit are needed. This is needed before the cattle can enter the Botswana Private Abattoir. If the cattle do not have the needed documents, it is sent back, and the cattle own is advised on the steps to take.

Lairaging

Cattle are offloaded, branded for identification using oil paint. After they are branded, they are lair aged according to the kraals holding capacity. Cattle must spend a night before they are slaughtered and antemortem takes place. The cattle's document is also checked for correspondence with the documents received from the gate receiving personnel. Cattle are then sorted according to the killing agenda prepared by the production manager. This section is risky because the operators are dealing with animal behavior. After they are sorted there are then guided into the racing cage based on the killing agenda.

If the cattle are excited or not fit to be slaughtered on that day, the inspector authorizes the cattle to enter using the emergency exit, where it would be slaughtered.

Production shop floor

Most of the activities take place, first, the cattle are stunned, hoisted, bleeding, dressing, skinning of the head, evisceration, offal separation, green offal washing, red offal washing, post mortem inspection, detaining, loading of a carcass, and tagging of skinned heads, weighing, issuing of establishment stamp, an inspection of hides and their sorting.

Problems identified in the existing process

Business process map of abattoir was captured and visual mapped, as the process was being mapped there were various issues identified within the process flow. Production recording and interview participants provided that their records show complaints that the abattoir records at the customer's side as they deliver the carcass. These complaints were recorded for two months (which were April and May 2018) given by three participants when answering the unstructured interview questions prepared. These complaints recorded are in Table 4-5 below;

Table 4-5: Complaints and issues recorded in a production line with their frequency of occurrence

Problems and Complaints	**Number of complaints recorded**
Missing carcass	10
Missing information of carcass	5
Undocumented process problem	4
Reported complaint on waste management	3
Labor assistance shortage	2
Unattended machine breakdown	1
Total	**25**

Figure 4-4 is a bar graph that further illustrates the above complaints given by the participants. From the bar graph, it shows that missing carcass recorded the highest number, followed by missing information of carcass due to improper capturing of carcass data.

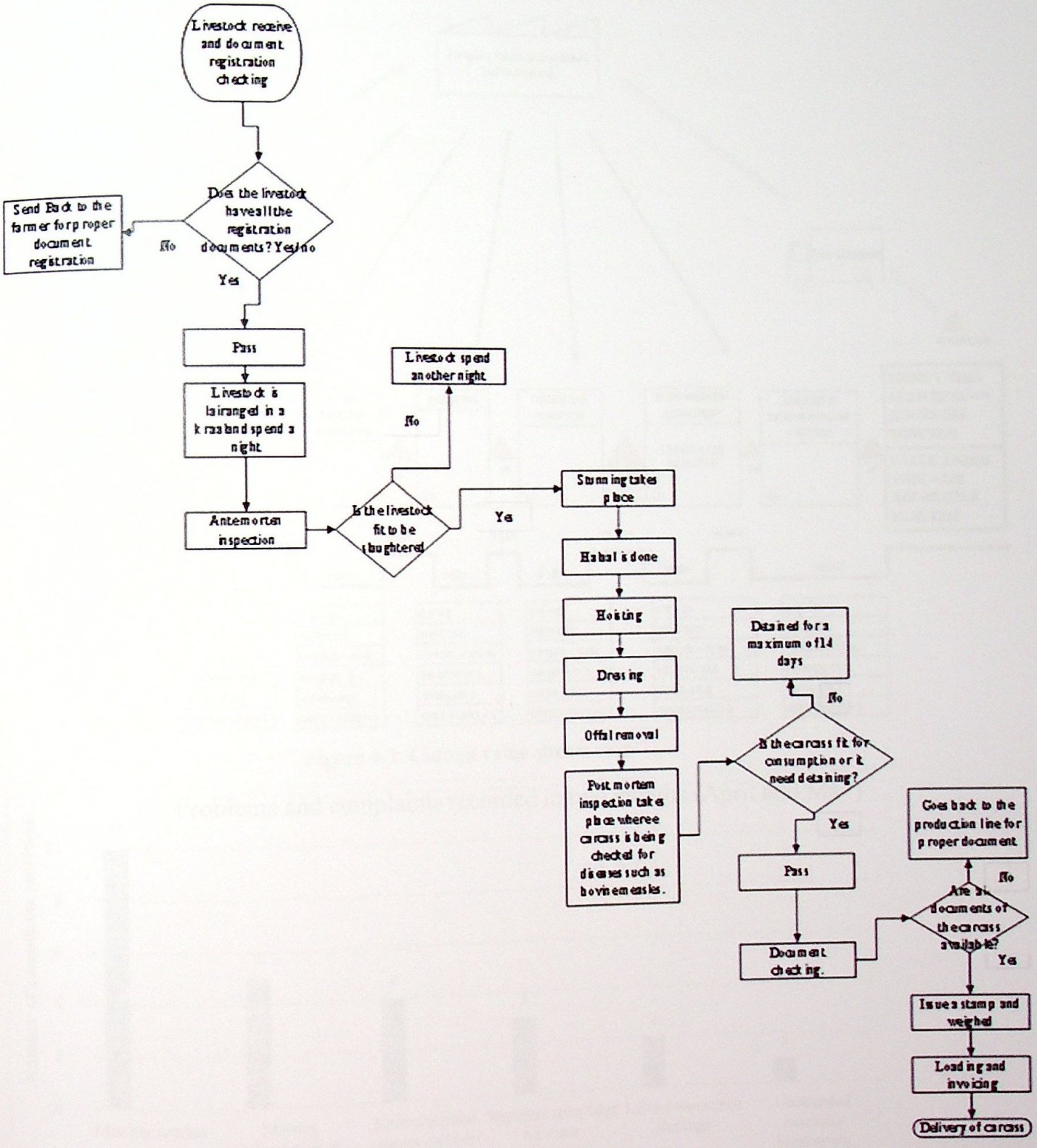


Figure 4-2: Current business Process map of Botswana Private Abattoir

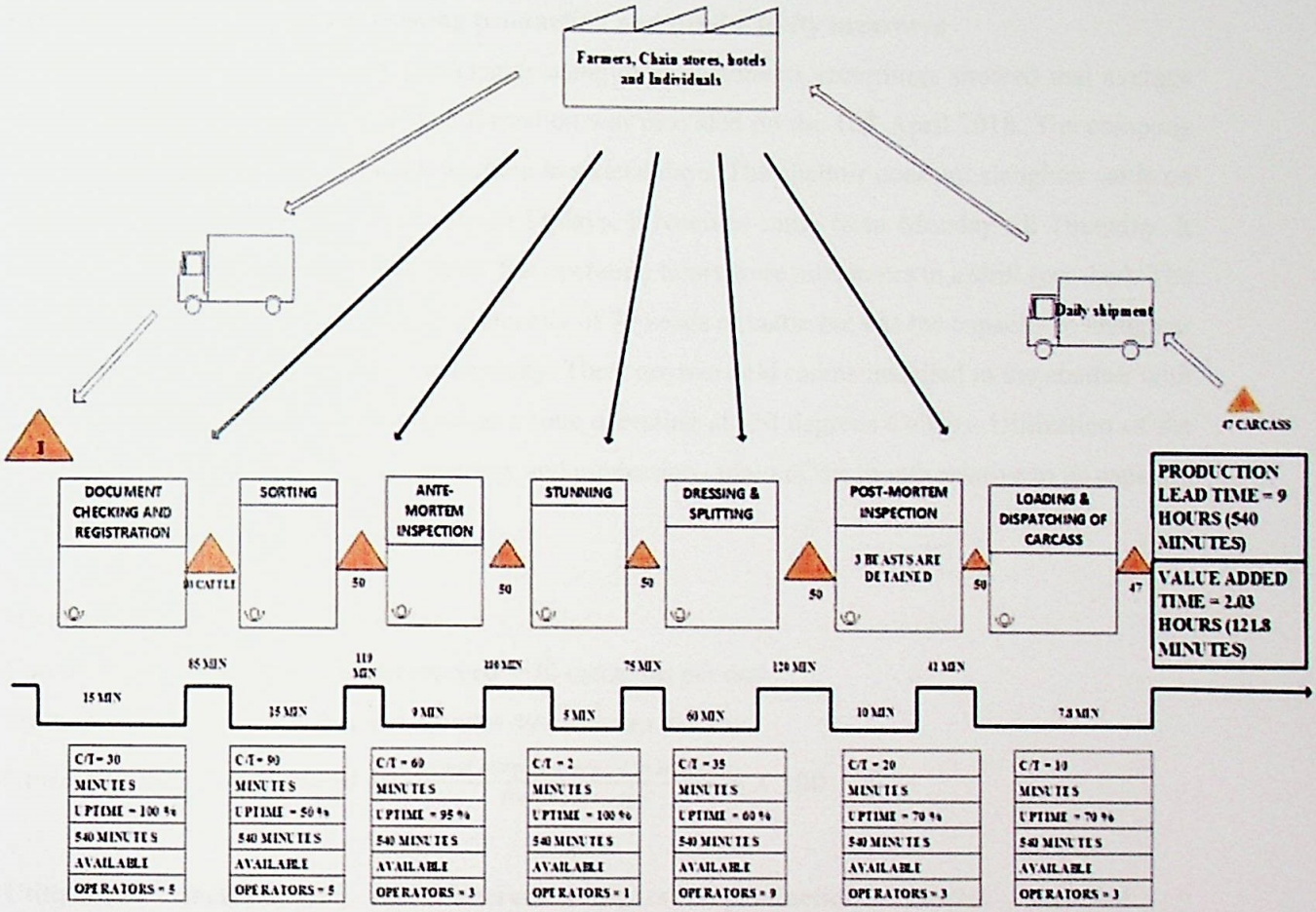


Figure 4-3: Current value stream map



Figure 4-4: Complaints recorded in the month of April and May

Document review on current existing production and productivity measures

Production analysis provided by participants using their documents recordings showed that average production is 41 cattle per day. This information was provided on the 12th April 2018. The company slaughtered 776 cattle on that month working in sixteen days. The abattoir does not slaughter cattle on Mondays, and it does not receive cattle on Fridays. It receives cattle from Monday till Thursday. It slaughters cattle on Tuesdays till Fridays. The operating hours were nine hours in a shift (per day). The abattoir has a current daily slaughtering capacity of 70 heads of cattle but has the capacity to slaughter a maximum of 100 beasts daily at full capacity. There are two cold rooms installed in the abattoir with a holding capacity of 100 tons of meat at a time operating at -20 degrees Celsius. Utilization of the holding capacity, current daily slaughtering, and production output of the month relative to its capacity were provided as below;

Holding capacity = 100 cattle per day

Current highest production output reached = 70 carcasses per day

Production output recorded in that month= 49 carcasses per day

Utilization factor is calculated as; $\frac{Actual\ output\ worked\ in\ a\ month}{Plant\ capacity}\ X\ 100$

Utilization factor of the current highest production output reached = $\frac{Actual\ output\ worked\ in\ a\ month}{Plant\ capacity}\ X\ 100$

$= \frac{70}{100}\ X\ 100$

$= 70\ \%$

From the analysis of the highly recorded production output recorded thus far, the utilization factor was 70 % and 30 %, the machines were not utilized.

Utilization factor of that chosen certain month

$= \frac{Actual\ output\ worked\ in\ a\ month}{Plant\ capacity}\ X\ 100$

$= \frac{49}{100}\ X\ 100$

$= 49\ \%$

From the analysis of the chosen monthly recorded production output recorded, the utilization factor was 49 % and 51 %, the machines were not utilized. From the fifty cattle that were slaughtered, only

forty-seven was in good condition and ready for delivery. Three of the carcasses was detained for four days because they had measles and were not good for human consumption.

Company audits and 5S workplace illustrations

Before 5S practice implementation there was a lot of unorganized & disarrangement of tools, scattered materials, and shortage of space. Company audits were done as part of the methods to identify workplace organization, some bottlenecks that the company experiences in its business process, and workplace safety issues. The 5S audit was done using a 5S scoring sheet as the tool for assessment and it is shown in Figure 4-5 below and audit checklist, See Appendix C. The purpose of the 5S audit is identifying issues of 5S which require attention and to be able to track the changes and measure the benefits brought about, through the 5S implementation. Scoring criteria were the only way that the author could use to show how the abattoir is performing in terms of its workplace arrangement and space utilization as they are key to productivity improvement and enhances the good working environment, safety and morale boost.

Score	Condition Observed	Score (check box) 0 1 2 3 4
4	Very Good (perfect condition)	
3	Good (1-2 problems)	
2	OK (3-4 problems)	
1	Bad (5-6 problems)	
0	Very Bad (above 7 problems), or non existent	

Figure 4-5: 5S scoring sheet

As audits were being done, pictures were taken in the plant in areas that are lacking in terms of good workplace organization. It was found that visual labels are not displays in some equipment and tools. It can be seen in Figure 4-6 below that there is a sign of a fire extinguisher, but the actual product is not there. There was also a reel without being indicated by labeling, according to the Safety regulations. Scoring was done, shown in Table 4-11 and it was found that safety regulation in terms of labeling and providing signs for tools was at a rating of 2.5 out of 4.

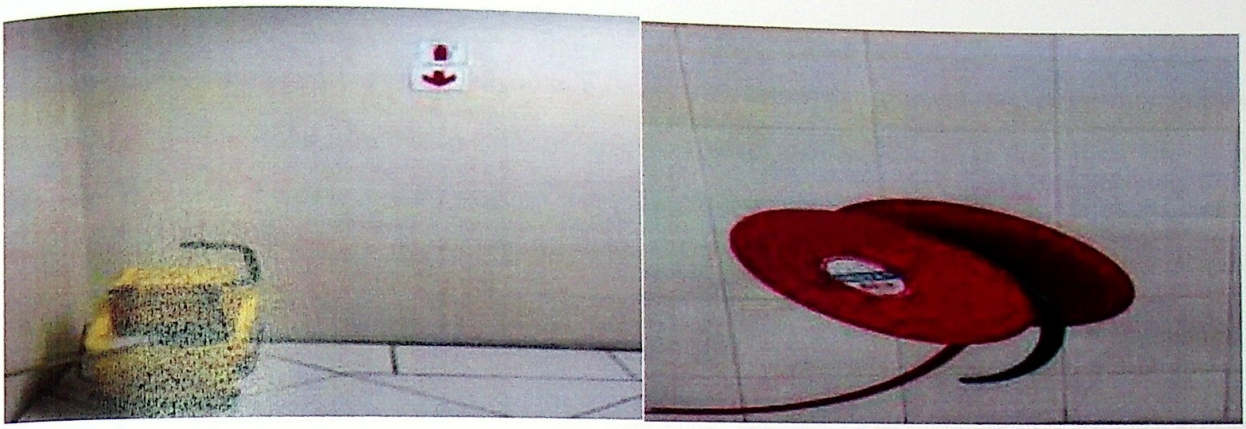


Figure 4-6: No labels of tools and signs not indicating the actual location of the equipment

Below in Figure 4-7 shows a photograph of cabinets that are not labeled, and the workplace shows some chipping of paint in the wall. To improve workplace organization and to avoid hazardous injuries, tools, items and should be ergonomically stored according to the 5S standard. Shelves and lockers are not clean and safety boots are just laying around., the team is not showing 100% ownership of the place by keeping the storeroom clean and organised, equipment is not stored properly and storage place is not labeled with sign panels. Scoring results in Table 4-11 indicate an unsatisfactory rating of ($\frac{3.5}{20}$) on each of the 5S phases especially the three being set in order, standardize and sustain ($\frac{0.5}{20}$). The low score was mainly due to having different materials and equipment in the production or shop floor section; cluttered on the floors and gangways at the facility.



Figure 4-7: No sign panels and floor markings and tools not ergonomically stored

Current facilities layout

Mapping the facility layout of the company was a way to provide visual guidance and recommendations on how the company can improve in terms of their workplace organisation and its utilization. Mapping a facility layout of the case study company was to help put emphasis on 5S performance charts, areas that need signage and visuals, and considering where each aspect of 5S audited and evaluated is lacking and making augmentative recommendations on how to improve 5S performance for visual communication and continuous improvement. The facility layout of the abattoir is shown in Figure 4-8, and it pinpoints areas that are not complying with safety regulations and standards. There are no fire extinguishers in the building, files in the offices are not labeled and indexed for easy retrieval of information and no safety awareness posters. In the production line; trolleys are not properly stored in a dermacated area, dust bins for waste are not labeled or color-coded according to environmental standards, storage tools are not properly stored with labels and signs. There are no sign panels in offices, emergency rooms, chillers where the carcass is temporarily stored after they are detained. Mapping the current layout helped to show the management wat kind of posters need to be put, placing of fire extinguishers, where to put sign panels and boards.

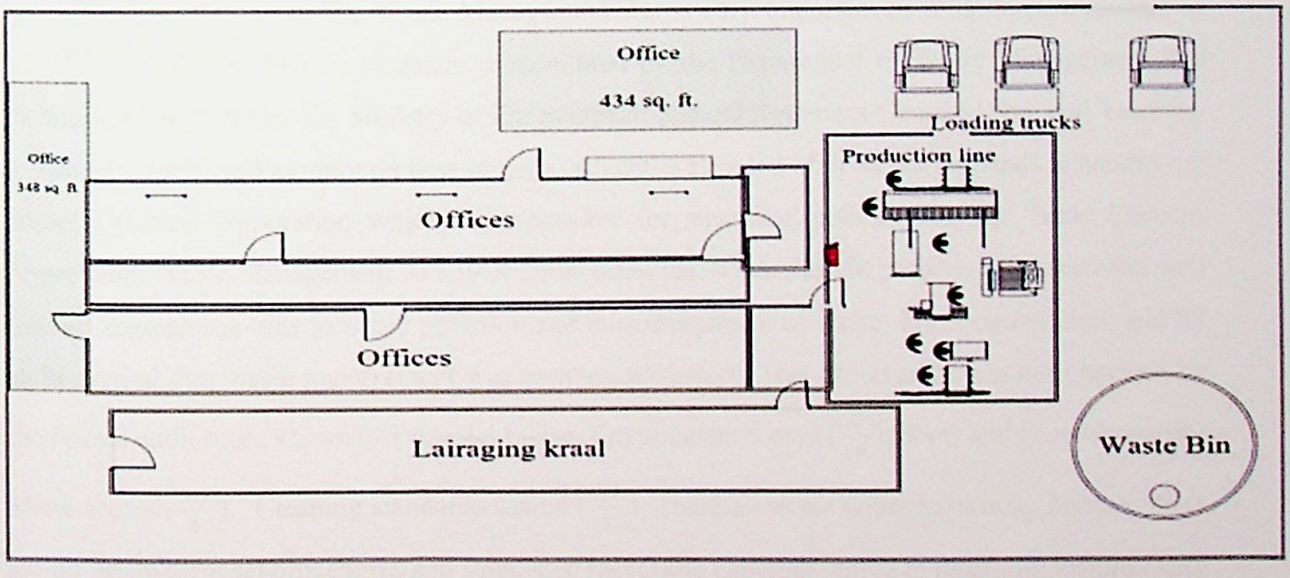


Figure 4-8: Botswana Private Abattoir facility layout.

Improper handling of electric cables

Figure 4-9 below shows an electric cable that is not properly insulated which is very hazardous to human safety and leads to machine breakdown. The cable that is illustrated below powers equipment

that is used in the private abattoir which implies that water or any liquid that is produced in the production line can get inside those cables and make electric shocks. According to the 5S standard, companies should always maintain a high level for safe workplace organisation so that employee's safety is not comprimised. Failure in managing cables was due to factors such as; trailing of unused wiring and cables, cables, and wiring were unorganised and not identified.

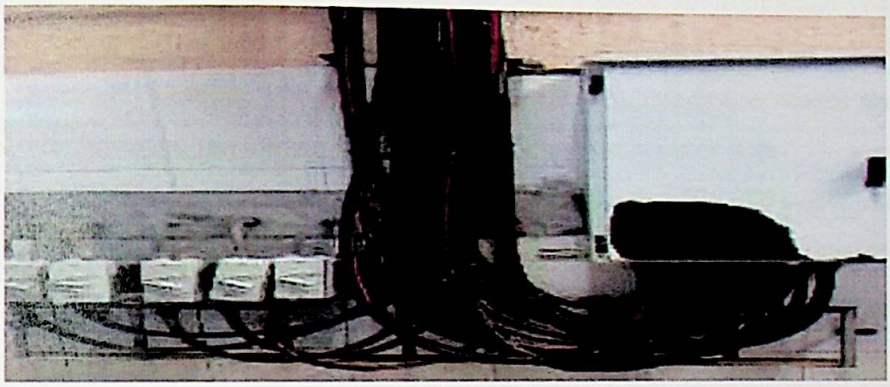


Figure 4-9: Improper managing of electric cables

No waste segregation bins

Segregating according to the Waste Management Act is very important as it shows compliance to standards. Waste in Private abattoirs is monitored by the Department of Waste Management and Pollution Control under the Ministry of Environment, Natural Resources Conservation, and Tourism. It inspects, audit, and monitor on how to trade effluent is disposed of. It works for hands in hands with Water Utilities Corporation which is responsible for amending policies like the Trade Effluent Agreement. Waste Management Act 59 of 2008, states that waste shall be properly disposed of in well labeled segregation bins to avoid pollution and mismanagement of waste. From observation, and 5S audit carried out; waste management was seen unsatisfactory. This observation was corroborated by the formal audit score shown in Table 4-11 were: Environment scored ($\frac{4}{20}$), floors and gangways under Shine scored($\frac{1.5}{4}$) Cleaning standards scored ($\frac{1.5}{4}$). These areas are underperforming because there are no waste disposal procedures and standards; recyclable materials stored in randomly together with non-recyclable waste material and containers are generic. There are no cleaning standards in place nor a dedicated cleaning station.

No red Red Tag station

A 5S red tag is a tool used to identify and call attention to broken tooling and equipment and point out unnecessary tooling, equipment, and material. From the 5S audit performance shown in Table 4-11, the Sort phase of 5S scored ($\frac{23}{60}$) while facilities scored ($\frac{4}{20}$)and red tag scored($\frac{0}{20}$).

Causes of waste

Slaughterhouse waste (or abattoir waste) disposal has been a major environmental challenge in the company. Observation and face to face interviews were used as methods to know what causes more waste in the company's abattoir. The chemical properties of slaughterhouse wastes are like that of municipal sewage; however, the former is highly concentrated wastewater with 45% soluble and 55% suspended organic composition. Blood has a very high COD of around 375,000 mg/L and is one of the major dissolved pollutants in slaughterhouse wastewater (Zafar, 2018). The solid slaughterhouse waste is collected and dumped in landfills or open areas while the liquid waste is sent to municipal sewerage system or water bodies, thus endangering public health as well as terrestrial and aquatic life. Wastewater from slaughterhouses is known to cause an increase in the BOD, COD, total solids, pH, temperature and turbidity, and may even cause deoxygenating of water bodies (Zafar, 2018).

High-level problems identified in a nutshell when conducting 5S pre-audit

i. Unsatisfactory arrangement of tools such as holding tray of the skinned head which consumes more transporting time thereby delaying the flow of work
ii. High absenteeism leading to the company not meeting its target

Process documenting

Before the research was conducted, the abattoir did not have a standard operating procedures and documented processes. The author first identified the process, documented it with a consultation with a lean six sigma expert and subject matter expert which on this case were production manager and his three-line supervisors. The process flow was mapped to capture activities in the workflows. Process documentation is a set of step by step operations compiled by an organization to help workers carry a routine operation (Feld, 2010). Standard Operating procedures aim to achieve efficiency, quality output and uniformity of process consistency and performance by reducing miscommunication, increase customer satisfaction, reduce failure to comply with industry regulations, simplify new employee training and improve employee satisfaction (Wilson, 2010).

Purpose & Scope

The purpose of documenting the process is to have a standardized operating procedure, to provide easy managing of process operations and to be able to adjust and improve working procedures. These Standard Operating Procedures apply to Botswana Private Abattoir from the time the cattle enter the building, stunned, and up until the carcass is delivered to the customer. Resources for these standard operating procedures are either skilled operators, reliable machines for production operation, company's business profile, action plans, and consistency measurement tools of process improvements.

Roles

Table 4-6 is a list of personnel and their roles who are involved in the delivery of carcass to customers.

Current Process description- Overview

Documenting processes for the case study company was one of the objectives. It defines the process steps that are involved in the slaughtering of cattle. It establishes the way in which these procedures are going to be reviewed, approved, frequency of revisions and review, document control, tracking and archiving. Table 4-7 shows steps involved at the gate where the cattle are received by security guards. After the cattle are received at the gate, the truck that is carrying cattles is then directed to the kraal, where cattle are lairage depending on their arrival. Below in Table 4-8 shows process steps at the lairaging kraal, from the time security guards allow cattles in the building.

Table 4-6: Roles for the compilation of standard operating procedures

Role	**Responsibilities**
Manager	Manages the delivery of each document deliverable
Sales Manager	Manages the delivery of each document deliverable and tracks deliverables through the process from development to approval
Production manager	Authorizes production to begin, set production target and assign tasks to supervisors
Human resource Manager	Assists in production and handle operators work related labor issues
Supervisors	Monitors production and allocate tasks to the operators accordingly
Security guards	Receives cattle's, monitors movement of goods and products, and check correspondence to all the needed documents
Operators	Provide slaughter service
Project team	Produces document deliverables

Table 4-7: Process steps involved when cattles enters the building at the gate

SECTION	STEP	OPERATION
RECEIVING CATTLE AT THE GATE	1	Opening of the gate to allow the delivery man to enter the building
	2	Offering greetings to the delivery man
	3	Inspecting the truck and cattle registrations
	4	Checking the correspondence of the cattle documents submitted by the delivery man
	5	Recording the information in the killing agenda book
	6	Cattle enter the building after all recordings have been captured

Table 4-8: Process steps involved at the lairaging kraal

SECTION	STEP	OPERATION
LAIRAGING	1	Offloading takes place
	2	Branding cattle for identification
	3	Lairaging
	4	Cattle spending a night
	5	Ante-mortem inspection
	6	Verification of papers
	7	Sorting of cattle

After cattle are lairage cattle are sorted according to the recordings in the books by the security guard at the receiving gate. Then operators guide cattle to the stunning box, where stunning takes place. In situations where the cattle are not fit enough, it is stunned in the emergency room rather than in the stunning box. Table 4-9 shows the process steps involved in the production line.

Below are briefly explained processes involved in the slaughtering of a beast. Appendix L is a list of all equipment and tools used in the slaughtering of cattle. Appendix M illustrates a detailed process of slaughtering a beast.

i. Receiving of cattle's: - Includes receiving any cattle size, checking the cattle's ear tags, registrations, cattle's movements, counting cattle receivables, allowing the cattle's in the building and giving farmers and customer's advice whenever necessary. The tools that are used are; pen, book, ruler, pencil. Security guards or designated personnel check the cattle's documents which are cattle's registrations, permits, affidavit, or letter from kgotla that indicates that the cattle belong to the owner. Pens, pencil, a ruler, and a recording book are used to record and capture the animal's information in the killing agenda book, as referred by the company's production manager. If the livestock has the needed necessary information, they will be allowed in the building. But before the livestock is captured, it should satisfy the necessary needed information.

ii. Lairaging: - It involves offloading cattle and sorting them according to the kraal's capacity. Tools that are used are; reader, sticks, pen, choker, ruler, book. Cattles are offloaded by the farmer. The employees brand them according to the farmer's owner for example if the cattle belong to Babedi, then they are branded BBI using oil paint. There are identified based on the killing agenda book because it is the one that captures the livestock's information. Cattles are then lairage according to the kraals holding capacity. After they are lairage and branded, cattle rest which is usually a maximum of twenty-four hours.

iii. Production shop floor: - It involves the slaughtering of a beast, stunning, bleeding, hoisting, dressing, skinning of the head, splitting, evisceration, offal separation, offal removal, postmortem inspection, meat inspection for food safety, issue of establishment stamp, weighing, invoicing, loading and dispatching. Tools that are used are; stunner, killing agenda book, and refer to Appendix L which lists all the equipment and tools used in the production shop floor.

The beast is stunned using a stunning machine, halaal is done by a prescribed specialist, and the beast is then hoisted for bleeding. After the beast has bleed, it is then skinned and dressed, the head is then transferred in a trolley to be systematically arranged. After the beast has been dressed it is tagged for identification, evisceration, offal separation offal removal takes place. The carcass is then washed, splitting, meat inspection, detaining takes place. It is then loaded after the establishment stamp is issued. The establishment stamp is the one that certifies whether the carcass is ready for human consumption. The carcass is invoiced, loaded, dispatched and delivered to the destined customer.

Table 4-9: Process steps in a production line

SECTION	STEP	OPERATION
PRODUCTION LINE	1	Stunning
	2	Halaal being done
	3	Hoisting
	4	Bleeding
	5	Skinning of heads
	6	Dressing
	7	Evisceration
	8	Offal separation
	9	Splitting of carcass
	10	Carcass tagging
	11	Head tagging
	12	Head sorting
	13	Red offal washing
	14	Green offal washing
	15	Red offal inspection
	16	Green offal inspection
	17	Carcass inspections
	18	Post-mortem inpections
	19	Report preparing
	20	Report issuing
	21	Detaining
	22	Truck inspection
	23	Weighing
	24	Loading of carcass
	25	Red offal loading
	26	Green offal loading
	27	Invoicing

iv. Weighing: - It involves weighing the carcass for invoicing. The weighing scale is used to weigh the carcass. Moreover the carcass is weighed to find its weight and for invoicing because Botswana Private Abattoir slaughters cattle of various sizes.

v. Loading: - It involves loading of skinned heads, green and red offal, and carcass in the truck for customer delivery. Refrigerated trucks are used to transport carcass to customers and before it leaves the abattoir, it is inspected to see whether the refrigerator is working or what.

vi. Meat inspection: - Carcass, red and offal meat are inspected for food safety. Cuts are made in the skinned head, green and red offal's, and carcass to inspect the carcass for disease conditions.

vii. Detaining: - It involves putting the carcass in a chiller for a maximum of four days, this is done to prevent measles that is found in the carcass after it has been inspected by a veterinary officer or a certified meat inspector.

Quality check: - Quality checking is one of the priorities of Botswana Private Abattoir because the company believes conforming to customer's specification enhances the good image of the company and increases sales, hence increasing profitability. Carcass, green offal, red offal, skinned heads, hoof, hides are checked after they are cut; it is done through visual inspection to identify whether there are some condemns or defects in terms of disease conditions. Antemortem and postmortem also shows that the company takes food quality and safety seriously.

4.2 Roadmap to lean implementation

This section provides the roadmap that was followed for lean implementation. The roadmap for lean implementation provides a guide for lean implementation that was used by the researcher, and it is shown in Table 4.10. The PDCA problem-solving approach was used as a framework to guide the implementation of the research project. This section describes the rationale for the application of specific procedures or techniques that were used to identify, select, and analyze information obtained from the case study company, to understand the research problem better. Lean implementation awareness was done through a research proposal to the company's management outlining the importance of lean tools and techniques to create the company's management buy-in and support. This enabled employees to ease their minds and make them aware of change management initiatives that are brought by implementing lean manufacturing tool in a beef abattoir.

Objective 1: To identify existing process, analyze and optimize it using lean manufacturing tools to achieve about 13 -14% process efficiency and workplace organization

For process mapping, non-value-adding activities of the two authorizations of carcass receipt by the operator and meat inspector were combined to be one activity that will be addressed by the operator by tagging the carcass and placing them in order of receival by first in first out (FIFO) method. Another delay time that was experienced in the production line, was due to unclear flow of work which was addressed by documenting the abattoir's process using the template in Appendix N. 5S practices were implemented using the PDCA methodology approach as a way to improve workplace organization. It was identified that the arrangement of tools, or equipment in the production plant is disorganised. Work study and time study were conducted to find non-value adding times and determine standard times so as to eliminate non-value adding activities.

4.3 5S Implementation

This section is about the implementation of 5S which is a lean technique that uses the 5S (Sort, set in order, Shine, Standardize and Sustain) to organize and maintain a neat and clean facility. Below in Figure 4-10 shows the roadmap to 5S implementation that was followed as a guide.

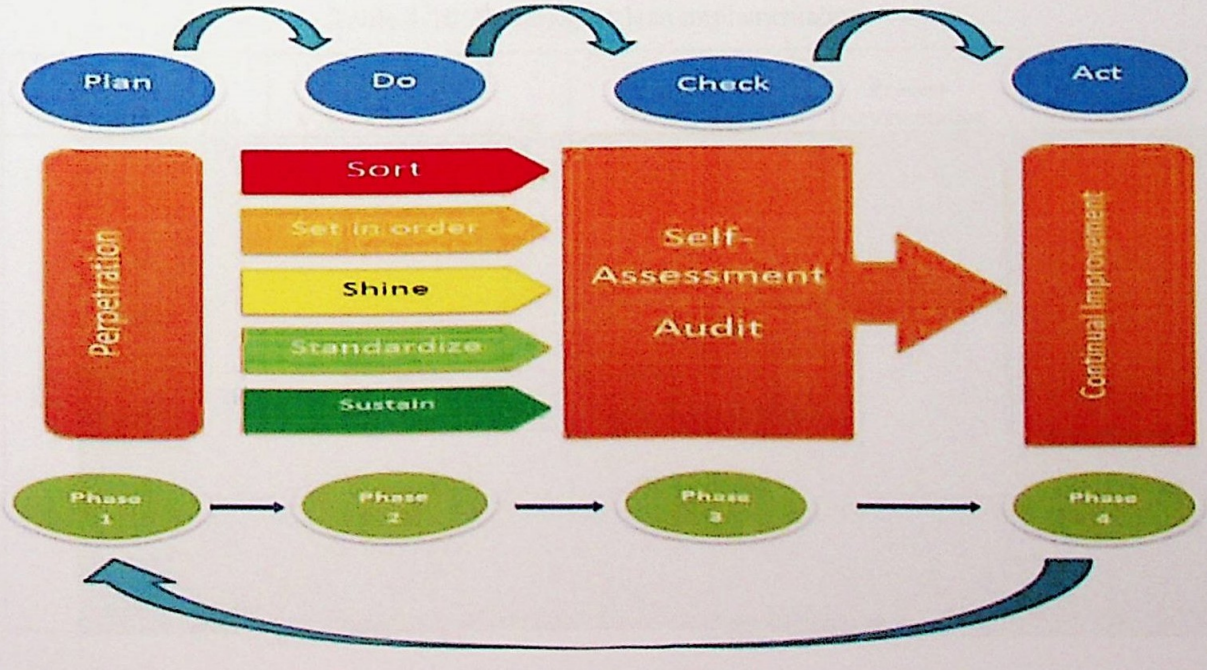


Figure 4-10: Roadmap to 5S implementation (Source: Administrator, 2018)

The meaning of 5S,

Sort- This means separating what is needed and what is not needed and keep only those things that are a need in the workplace. Discard unnecessary items

Set –in order- Neatly place and identify needed work items. Designate a place for everything so that anyone can find it. Always put things back in their designated spots

Shine- clean up. Always maintain a clean and shine workplace. Identify why are things are getting dirty.

Standardize- Become a role model for adhering to the standards of the first three S's and encourage others to follow them. Make rules and procedures to promote a good working environment until the first three S's become everybody's second nature.

Sustain- Maintain and practice the first four S's. Be thorough in straightening up, putting things in order and cleaning.

Table 4-10: Roadmap to lean implementation

	PDCA Cycle	Value Stream Mapping	Work Study	Process Documentation	5S
Plan	Objectives	-Review of business strategy and key metrics -Mapping the current business and production process	-Understanding the production process -Preparing method and time study plan	-Determining key business metrics - Map the current high-level process - Draft business and production process for future documentation	-Carrying out a 5S audit for each section -Evaluation of the 5S audit -Evaluation of the 5S audit - Plan 5S action plan -Taking photographic images before lean implementation

Do	Objectives	-Consult with process users and top management on the mapped processes - Map future state	-Determine the standard time of slaughtering a cattle/ beast - Map future state - Carry out motion and time study	-Consult with top management for drafted process documentation - Await authorization and reviews from process users and top management	- Red tagging - Do 5S campaigns - Make awareness on 5S - Make recommendations on 5S lean implementation - Draft 5S training awareness
Check	Objectives	Document the future state		Await authorization and reviews from process users and top management	Carry out 5S Re-audit to check the effectiveness
Act	Objectives	Make recommendation for the future state to be considered for improvements	Set the production standards	Agree on timelines for reviews, audit for future documentations	Place recommendation measures to ensure good performance

4.3.1 5S Objectives and goals

5S objectives were set as it is important in the implementation of 5S to guide the success of the 5S implementation. The main objective of implementing 5S is to create a clean, orderly environment; an environment where there is a place for everything is in its place. Target goals of the implementation are to;

- reduce non-value adding activity and navigating allocating tools, parts and supplies
- improve floor space utilization, employee safety and moral
- extent equipment life through more frequent cleaning and inspection

Table 4.11 below shows the performance of abattoir in terms of 5S practice after the 5S audit was performed using the 5S scoresheet. The director, the production manager, and the researcher(i.e three individuals) independently audited the facility using the 5S checklist, see Appendix C. The findings of the three individuals were averaged out to combat bias.

Radial charts in Figure 4-11 below were created for each of the phases of 5S to further analyze how each element of the assessment area is performing in each phase. Doing so enabled to pinpoint performance of elements in each phase. It showed that there is a lot that needs to be done in terms of implementing 5S practices. The radial chart explains that there are a lot of unnecessary tools in the plant that needs to be red-tagged. This helped in the 5S implementation roadmap. The performance of 5S in Botswana Private Abattoir is seriously lacking in all aspects of 5S. Standardization and Sustain

phases of 5S because the performance was very unsatisfactorily during company audits. Assessing the individual aspect of the criteria, a bar graph, and a Pareto chart were constructed to give a clear look at how each criterion was performing. The criterion elements were sorted in ascending order so that the best performing area can be easily recognized. Workbenches and surfaces performed better than any other criteria, scoring $\frac{15}{20}$, followed by Health and Safety scored $\frac{14}{20}$ quantified in percentages like 75% and 70% respectively, which is in good condition and much appreciated. Some criteria areas including; Cleaning standards, mobile equipment, tooling, fixtures and jigs, wire, cabling & hoses performed to close to the average performance which is fifty percent (50%) at average mark score and they need some improvements too.

The line graph was used as an analysis to illustrate areas that create problems and lacking behind in 5S. Figure 4-12 illustrates 5S criteria performance in all criteria areas, and there are about four areas that have low scores which are due to; unneeded items not red-tagged, no visuals, labeling of hazardous items in the production facility and lack of integrated carcass tracker in the production line. These areas affected 5S performance during 5S assessment. Implying that 20% of critical areas contribute to 80% unsatisfactory performance.

Table 4-11: Audit performance (refer to Appendix C for assessment form)

Criteria (AREA)	**SORT(/4)**	**STRAIGHTEN (/4)**	**SHINE(/4)**	**STANDARDIZE(/4)**	**SUSTAIN(/4)**	**TOTAL(/20)**
Healthy and Safety	3	2.5	3	2.5	4	13
Environment	1.5	1	1	0.5	0	4
Facilities	1.5	2	0.5	0.5		4
Floors and gangways	1.5	0	1.5	0	0.5	3.5
Duty technian	0	0	0	0	0	0
SHE officer	0	0	0	0	0	0
Tooling, fixtures and jigs	3.5	1.5	2.5	0	0.5	8

Wire, Cabling & hoses	2.5	2	1	1	1	7.5
Work benches & surfaces	3	3	3	3	3	15
Visual tracking boards	0	0	0	0	0	0
Production boards	0	0	0	0	0	0
Red tag	0	0	0	0	0	0
Mobile equipment	3.5	1.5	1	1	1	8
Cleaning standards	3.5	1.5	1.5	0.5	1	5.5
Intergrated tracking device of a carcass	0	0	0	0	0	0
Total	22	13	14.5	8.5	11	69
Overall	60	60	60	60	60	300

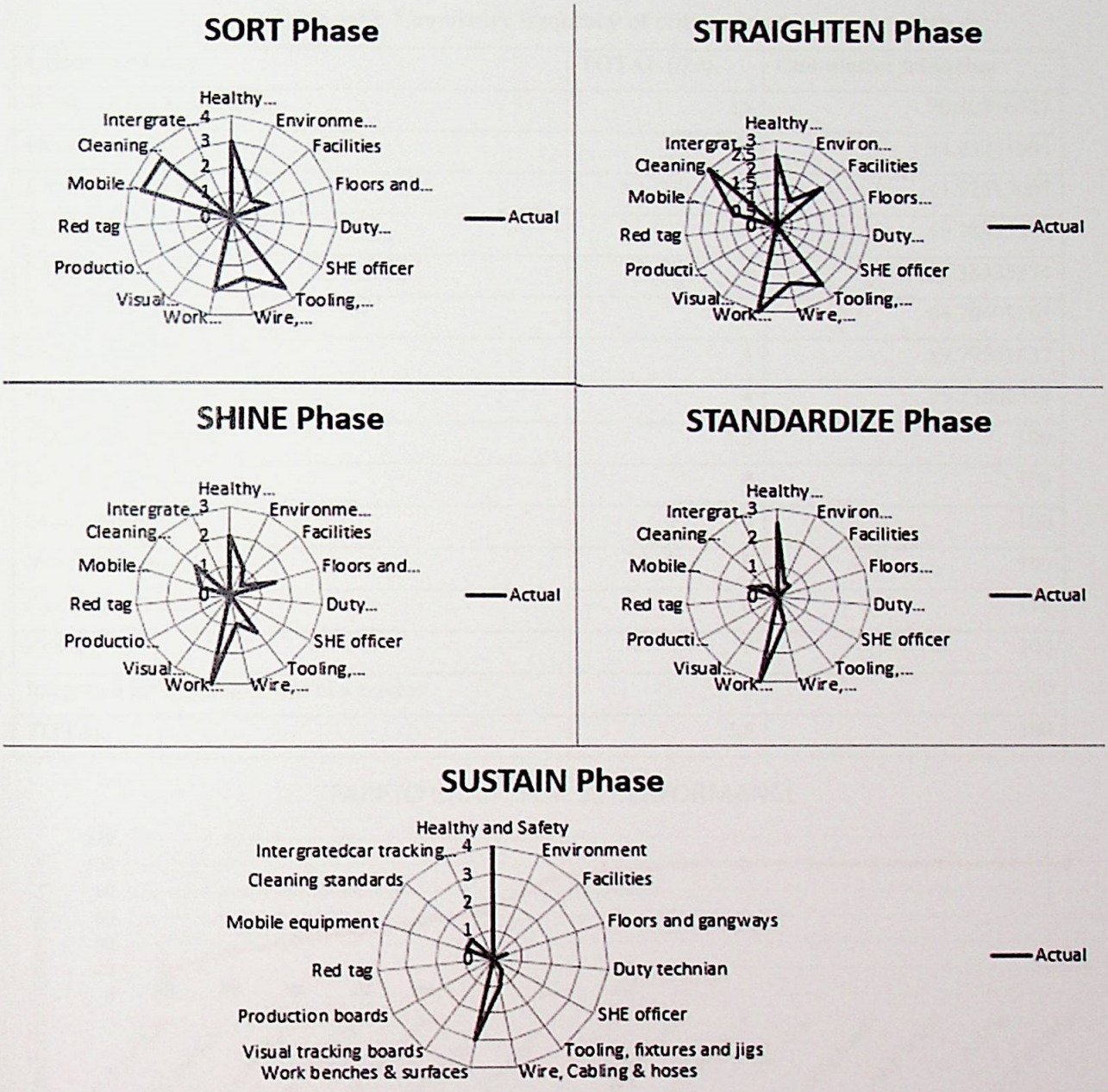


Figure 4-11: Radial charts of 5S phases in summary

Pareto chart was used for this analysis to illustrate areas that are major contributors to poor workplace arrangement in a beef abattoir, and these areas contribute to 80% of 5S to perform unsatisfactorily. Those areas scored 10 points and below on a total score of 20 points within the 5S's in summary. Table 4-12 below shows a cumulative frequency of the criteria areas.

Table 4-12: Cumulative frequency of criteria areas

Criteria (AREA)	TOTAL (/20)	Cumulative frequency
Workbenches & surfaces	15	20.40816327
Healthy and Safety	14	34.04761905
Cleaning standards	9.5	41.92517007
Tooling, fixtures and jigs	8	49.38435374
Mobile equipment	8	57.38435374
Wire, Cabling & hoses	7.5	64.70408163
Environment	4	89.79591837
Facilities	4	95.23809524
Floors and gangways	3.5	100
Duty technician	0	100
SHE officer	0	100
Visual tracking boards	0	100
Production boards	0	100
Red tag	0	100
Integrated car tracking device of a carcass	0	100
TOTAL	**73.5**	**100**

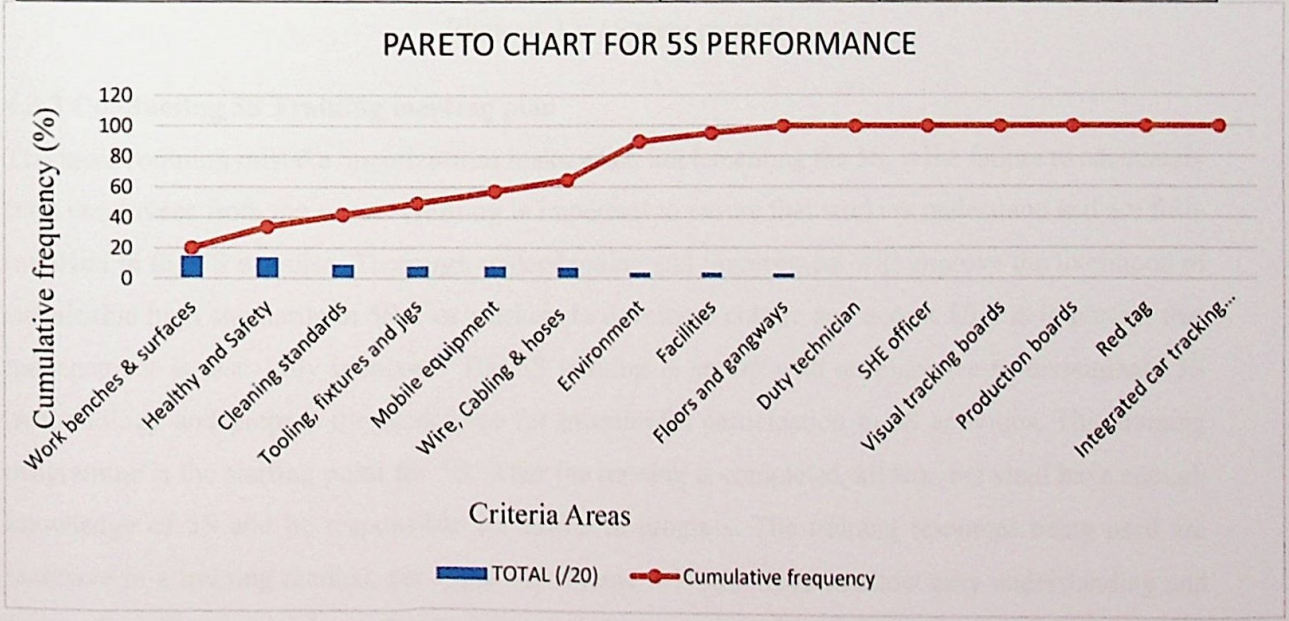


Figure 4-12: Pareto graph for 5S performance results

4.3.2 5S Council

In order for 5S practices to be successful, commitment, participation, and involvement of everyone are vital and most importantly strong visible support from the top management. The 5S council is formed to enhance the total participation at all levels of employees, to develop continuous improvement culture and best performance spirit in the teams and it is illustrated in Figure 4-13. The 5S implementation responsibilities were distributed across the staff members. The steering committee is responsible for selecting, assisting in conducting training, sharing information, and assisting in developing the 5S plan. Before the 5S council, a proposal letter was issued to the company requesting the 5S council to consist of two-three individual that is two beef abattoir's staff (production manager and the director) and the researcher. This letter is shown in Appendix E.

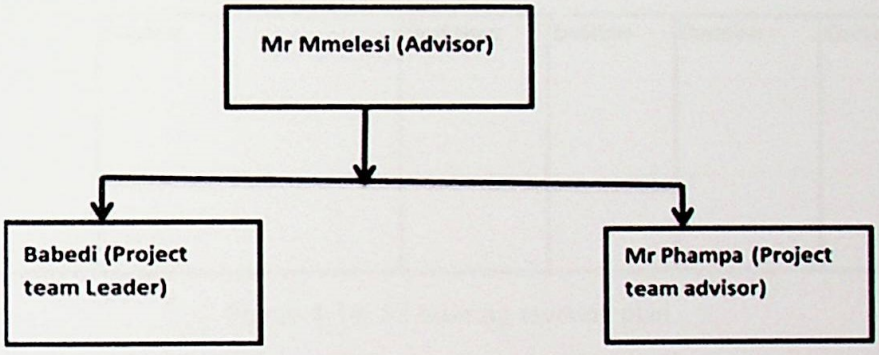


Figure 4-13: 5S team council

4.3.3 Conducting 5S Training meeting plan

The most common mistake organizations make when implementing the 5S, is the failure to adequately train employees from the onset. Training is important to ensure that workers understand and are fully involved in the 5S exercise. Thorough understanding and involvement will improve the likelihood of sustainable high standards in 5S. For workers to develop a culture and accept 5S it is important that management is also fully involved. The 5S training is set up with an objective to disseminate 5S methodology and prepare the workforce for meaningful participation in 5S activities. This training programme is the starting point for 5S. After the training is completed, all workers woul have enough knowledge of 5S and be responsible for action in progress. The training resources being used are inclusive in a training manual, see Appendix F, and it is simplified to allow easy understanding and grasp of concept by workers. One training was done on the 18th April 2018 on safety and wellness (HACCP) and the mandate of this training was to make employees ware of their safety and awareness when working in the plant. The 5S training meeting plan conducted is shown in Figure 4-14. 5S training

meeting plan was conducted to brief on aspects involved in 5S such as change management initiative, conducting of red-tagging, and brainstorming on ideas that can be brought forward during the 5S training day. The proposed 5S training document manual was prepared for future use in the company and it is shown in Appendix F.

TRAINING PLAN FOR 5S IMPLEMENTATION					
EXECUTIVES:	PRODUCTION MANAGER, PROJECT TEAM MEMBERS, SUPERVISORS, PRO				
PREPARED BY:	BABEDI KUFIGWA				
DURATION OF TRAINING:	TWO WEEKS				
RESOURCES:	STATIONERY, COMPUTER, ACCESSORIES, DRINKS AND BEVERAGES, SNACKS				
VENUE:	JAGO BEEF ABATTOIR BUILDING				
START TIME:	1500 HRS				
END TIME:	1530 HRS				
PURPOSE:	To provide knowledge and make employees aware of 5S and its implementation				
List of activities	**Purpose**	**Start time**	**Endtime**	**Duration**	**Comments**

Figure 4-14: 5S training meeting plan

4.3.4 Summary of 5S progress

The PDCA methodology framework was used in the 5S implementation plan. Table 4-13 below shows an overall overview of the activities completed and those that are still in progress under 5S. 5S was not completely implemented because the abattoir was not ready to implement the last two S (Standardize and Sustain) and it was constrained by its budget. Recommendations and proposed the 5S training manual were provided to the company to consider 5S completion project in the future. Suggestions were done so as to provide guidance and a source of reference when the company is ready to fully implement all phases of the 5S practices.

Table 4-13: 5S implementation status

Step	PDCA methodology	Phase	Description	Status
1	Plan	Prepare	Perform the 5S Audit checklist	Completed
2	Plan	Prepare	Develop a 5S council	Completed
3	Plan	Prepare	Conceptual plan of implementation	Completed
4	Plan	Prepare	5S training of the staff of the company	Completed
5	Plan	Prepare	5S launch(Objectives and mission)	Completed
6	Plan	Prepare	Taking before 5S photographs	Completed
7	Do	Sort	Identify the wastes using the waste identification form(worker should answer these questions: what do I need to do my work? Where should I locate this item? How many of this item do I really need ?) see Appendix D	Completed
8	Do	Straighten	Visually mark the specified place for everything	Partially completed
9	Do	Straighten	Define aisles way, work stations and storage areas (use floor tapes if available)	Partially completed
10	Do	Straighten	Dermacate the zones(layout of the entire work area into storage, production floor etc)	Partially completed
11	Do	Straighten	Prioritize frequently used tools and materials	Recommended to be done
12	Do	Shine	Clean and order	Recommended to be done
13	Do	Standardize	Visual aids(signboards, colour coding or outlining)	Recommended to be done
14	Do	Sustain	Process document	Recommended to be done
15	Check		Re-audit, improvement measurement	Recommended to be done
16	Check		After 5S photographs implementation	Recommended to be done
17	Act		Periodic 5S reassessment	Recommended to be done

4.4 Work method (method study and time study)

A time study was conducted to specific work tasks to help identify set up and operating time's improvements. To eliminate non-value adding activities and unnecessary transport time; the length of process operations should be balanced with standard times determined. A sample of three employees were selected from each section that is skilled, semi-skilled, and unskilled personnel. Five cycles were observed and then averaged, the averaged time was later multiplied with an allowance rate of 15% to

give standard time. The time study data collection sheet, observed time, and standard times are shown in Appendix I, Appendix J, and Appendix K respectively.

Time study and motion study was conducted at the abattoir for the slaughtering process, i.e activity times were considered from the time, the cattle enters the building up until they are loaded in refrigerated trucks for delivery to the designated customer. Time study was conducted on three consecutive working days for the nine hours working shift. A stop watch technique was used. When using this technique actual times required to perform different activities were recorded in their elemental form and according to the steps involved in the slaughtering of cattle. Three employees were selected from each section that is skilled, semi-skilled, and uskilled personnel per each operation and were timed. The reason was that the supervisor allocates task according to the availability of work content. For example, if there is more work content in splitting of the carcass, one operator would be shifted to that section to add labor intensity. Tools used for conducting time study are digital and electronics stop watch, board for holding time study sheet, video camera recorder, observation time study sheet and stationary such as pen, pencil, eraser and calculator. After actual times were recorded, data was analyzed so as to obtain the time necessary to carry out a specified job at a specified level of performance rating and specified allowance such personal, fatigue and delay (abbreviated as PFD allowance). The performance rating was taken to be 100% and PFD was taken as 15% as stated by the International Labour Organization (O'Rourke, 2003). A sample size of 5 beasts and five cycles were selected and recoded their times for accuracy. Five observed cycle times were recorded and averaged. These observed cycle times data is shown in Appendix J. Time study was conducted to identify areas for cycle time improvements. In Appendix K is a table showing standard times of slaughtering a beast and elements per categorized section for slaughtering a beast.

Selection of product to conduct a time study

The abattoir provides slaughter service for two different animals which are goats and cattle. Selection of which product to time was mainly based on the economic and technical aspects. Economically, cattle are the ones that bring more income to the company. Technically, when time study was conducted cattle was the one which was having more production on that week. Cattle slaughtering experiences more bottlenecks and problems compared to small livestock production and it was agreed upon consultative meeting to conduct time study on cattle slaughtering process.

Recording the facts

Data recording was the most difficult step for the success of the whole procedure. It entirely depended on the accuracy of the accuracy with which the facts were recorded, the basis of which would provide a critical examination and the development of the improved method. The recording was done using observational time study sheet form, two-handed process chart, and process flow chart. The first step which was done in time study was to map and identify a detailed analysis of the operation flow through direct observation. This entire process was then broken down into elements. This was done to identify the non-value-adding activities(also known as non-productive activities) and separate them from value adding activities (also known as productive activities).

Standard-Times

The time taken by the operator to perform each element of the operation was measured using a stopwatch and was recorded in a time study sheet. The time study sheet used is shown in Appendix I. Slow pace operator, medium-pace operator, and fast-pace operator were timed during time study. In some elements of operations: slow pace operator, medium-pace operatorand fast pace operator were timed and averaged to get one observed time. Upon determining standard time; cattle spending a night, offloading and detaining carcass were not included because there are other activities that interfaces within this process but are done a day before at the owner's expense.

Motion study

Maynard Operating Sequence Technique (MOST) was used as a work measurement technique that compiles the work standard time and maximizes resource utilization by improving the working method. To do this, a video camera recorder was used on the workshop floor of Botswana Private Abattoir to capture video footage of the nine-hour working operating shift. MOST Indexes was recorded in time measurement unit (TMU) and in seconds, as 1 second is equivalent to 28 seconds. Table 4-14 shows the motion study results recorded in terms of the eighteen motions that were developed by Gilbreth. The scope of the motion study was limited to the production line, since it was the one was more transporting time of carcass that delays the flow of carcass within the production line. Results of motion study were tabulated in Appendix H. It was identified that most operators use their backs to carry skinned heads to the hanging trolley where they are inspected for diseases.

Table 4-14: Summary of motion study results (in minutes) using therbligs

Section	S	F	P	PP	TL	H	AD	SE	I	G	UD	RL	R	U
Receiving	3	2	2	1	0	1	45	2	5	4	4	23	20	5
Lairaging	23	10	24	14	20	15	40	23	35	12	40	10	34	30
Production	25	12	24	27	31	50	34	36	60	56	57	15	66	45
Total	**51**	**24**	**50**	**42**	**51**	**66**	**119**	**61**	**100**	**72**	**101**	**48**	**120**	**80**

Table 4-15 shows a summary of standard times. Results show that 126 minutes is taken to produce one beast ready for delivery to customers or butcheries (production lead time), and the reason they spend this much time is that there is a lot of queuing in the production line. The research company also losses most of its time doing nothing(i.e resting) and avoidable time. Meanings for the above-used symbols are S-searching for a tool, F-finding a tool, P-positioning a tool, product or worker,TE-transport empty, PP-prepostioning, TL-transport loading a product, H-hold a product or a tool, AD-avoidable delay, SE-selecting a tool to use, I-inspecting a product or any work adding value related to the product, Grasp-grasping a tool to use, UD-unavoidable delay, RL-releasing load, R-resting and U-using a tool.

From the standard time, it takes one hundred and twenty-six (126) minutes for one beast to be loaded into the truck to the customer or for the carcass to be handed to the owner. It is thus a long manufacturing lead time.

Table 4-15: Summarized standard times in each section

Section	Standard time (in minutes)	Standard time (in seconds)
Receiving	5	300
Lairaging	44	2640
Production	77	4620

Table 4-16: Summary of standard times in categorized sections

Section	Operation	Standard time (in minutes)	Standard time (in seconds)
Receiving	Receiving of cattle	5	300
Lairaging	Offloading	20	1200
	Branding cattle for identification	5	300
	Lairaging	11	1440
	Cattle spending a night	1440	86, 400
	Ante-mortem inspection	12	1800

	Verification	13	720
	Sorting	3	180
Production	Stunning	1	60
	Halaal being done	2	120
	Hoisting	1	840
	Bleeding	2	120
	Skinning of heads	5	300
	Dressing	4	480
	Evisceration	3	540
	Offal separation	4	240
	Splitting of carcass	4	240
	Carcass tagging	1	60
	Head tagging	2	120
	Head sorting	3	180
	Red offal washing	2	120
	Green offal washing	3	180
	Red offal inspection	2	120
	Green offal inspection	3	180
	Carcass inspections	2	120
	Post mortem inpections	4	360
	Report preparing	2	120
	Report issuing	4	240
	Detaining	5760	345,600
	Truck inspection	5	300
	Weighing	4	240
	Loading of carcass	4	240
	Red offal loading	2	120
	Green offal loading	3	180
	Invoicing	4	300
Takt time			
	Takt time	7.71	463
Standard time	**Total Standard time**	**126**	**7560**

Objective 2: Carry out value stream mapping for the organization to identify bottlenecks

Value stream mapping was done to eliminate any pitfalls that exist within an operation. Absenteeism, not meeting the production target of 70 cattle in a day and a mixture of carcass within the production line were issues that the production operation was experiencing.

4.5 Value Stream Mapping, Takt and Cycle times

This chapter illustrates the value stream that was captured during interviews conducted with the help of process flow charts supported with time study for recording the duration of activity times in the value chain. Operations of the abattoir were not standardized, and the operators do not have an output requirement per day, and this led to work imbalance. Since each carcass process is charged at a carcass

(delivered) per rate. Most of the time the abattoir was not meeting its averaged target of 47 cattle in a day and it was forcing them to overlap their production / carcass delivery to the next day or render employees' overtime. The current or existed value stream by that time was mapped to understand material and information flow. Based on the current state map, direct observation, and the information given by the production manager, a value stream map is shown in Figure 4-3; and it shows that waiting time is far greater than the value-added time, thus increasing the lead time, high queuing time and operating costs. Based on the available work identified through work measurement and customer demand, Takt time was found to be 463 seconds based on the company's design capacity and set a target of 70 cattle per day with a production time of 9 hours in a day. Takt time means that in order to meet customer demands, Botswana Private Abattoir needs to produce a carcass every 463 seconds and it is shown in Figure 4-15. This is a reference number defined by the customer and it should improve processes to match this time considering downtimes, changeovers, and defects. The current operator balance chart was determined using the number of operators that are engaged at the receiving gate, lairaging and production line given by the Human Resource Department. The current operator balance was used to help reduce idle time and this is shown in Figure 4-16. Based on the current worker balance it shows that there are bottlenecks in the production shop floor that hinders the abattoir to meet its production target.

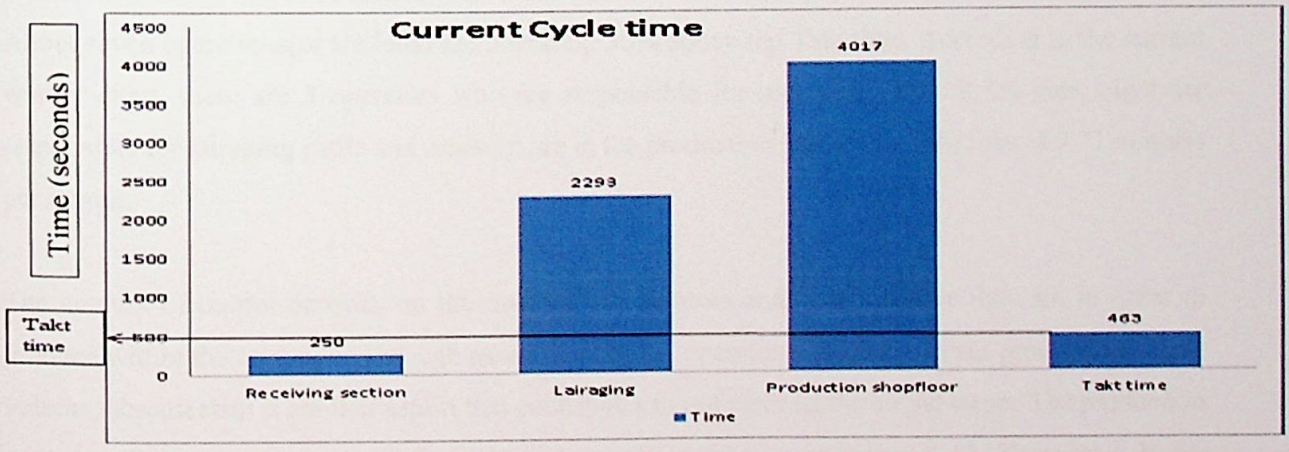


Figure 4-15: Current cycle times

Current worker balance chart

A worker balance chart is a visual display of work elements, times, and workers at each location to show improvement opportunities in relation to value stream cycle time and takt time. To make worker balance chart; cycle times were recorded and the current workers involved in that operation, i.e "AS-

IS " based on their load of operation, as it is shown in the current state map. Figure 4-16 shows a worker balance chart which shows the need to redistribute workers as there are more idle times within the production line.. This will eliminate idle time and queues at some processes with more cycle times.

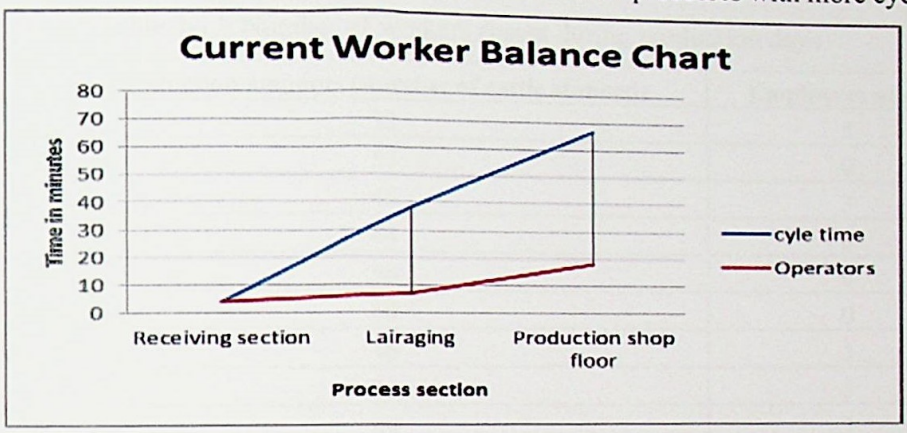


Figure 4-16: Current worker balance chart

The current baseline or current condition at Botswana Private Abattoir was established for all 28 operators within the studied area. The current state was determined through actual operators' observation and time study. Based on the current information obtained the average overall process efficieny is 22.5% and utilization is 49% (compared to the facility existing current records of 45% process efficiency and 50% utilization). Observed times for each process are shown in Appendix J. About seven operations(or stations) are operating 30% above the Takt time. According to the current worker chart, there are 3 operators who are responsible for receiving cattle at the gate, eight are responsible for lairaging cattle and nineteen are in the production line with a Takt time of 7.71 minutes per output.

The amount of output depends on the number of operators and how effective they are in order to produce within the set target. Through assessment of the operator attendance versus production output volume, absenteeism is another aspect that contributes to not meeting the output target. The production output and absenteeism were illustrated using graphs as shown in Figure 4-17. The output levels decrease with increasing absenteeism as shown in the graph. Table 4-17 shows the production amounts (cattle slaughtered) against worker's absenteeism during production days given a nine-hour production. These current state values were determined by interviewing production with the help of production records. Furthermore, a cause and effect diagram in Figure 4-18 was used to determine the root causes of not meeting the production target which is another ultimate problem that the company wanted to

overcome. Through the use of cause and effect diagram, the problems were identified in terms of methods, machinery, environment, and manpower in order to address the root cause.

Table 4-17: Number of workers absent during production days

Days	Production amounts (number of cattle stunned)	Employees absent
Day 1	32	5
Day 2	57	0
Day 3	45	3
Day 4	44	0
Day 5	56	0
Day 6	60	0
Day 7	46	3
Day 8	36	5
Day 9	49	3
Day 10	45	0
Day 11	44	3
Day 12	42	4
Day 13	46	2
Day 14	46	3
Day 15	52	0
Day 16	50	1

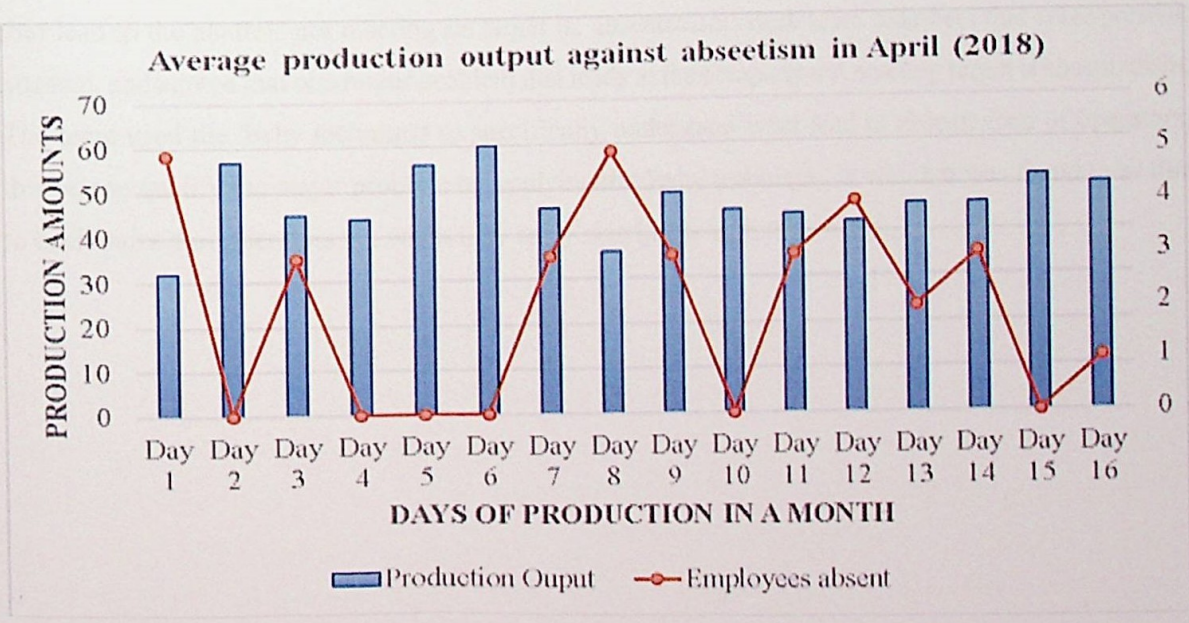


Figure 4-17: Graph of production for the month of April 2018

Table 4-18: Current state of the value stream

	Current State
Total lead time	9 hours
Value Percentage of time (value-creating a time of total time)	22.56%
Percentage Quality Screen (% defectives at the downstream)	20%

Table 4-18 summarizes the current value stream map which was determined using time study exercise, abattoir's recorded data and document analysis so as to know how much value the abattoir was at before eliminating non-value adding activities/ inefficient operations.

Cause and effect/fishbone analysis was a technique that was used to investigate why the abattoir does not meet the production target for the day. A team comprising of production manager, three-line supervisor and three operators on the 4th October 2018, were put in a one-room in a form of a brainstorming session so as to find the causes and subcauses that are leading to the abattoir not meeting the target. Figure 4.18 shows a variety of causes and it was found out that the major/persisting problem that lead to the abattoir not meeting its target is; absenteeism. Both team members that were present, attested, and agreed that one major problem that leads to the company not meeting target is absenteeism. The team used the 5why technique to specifically understand what lead to absenteeism of operators, this was to qualify the major problem by applying the 5why technique, in which it was found to be due to back pains that operators get when they carry skin heads with their backs.

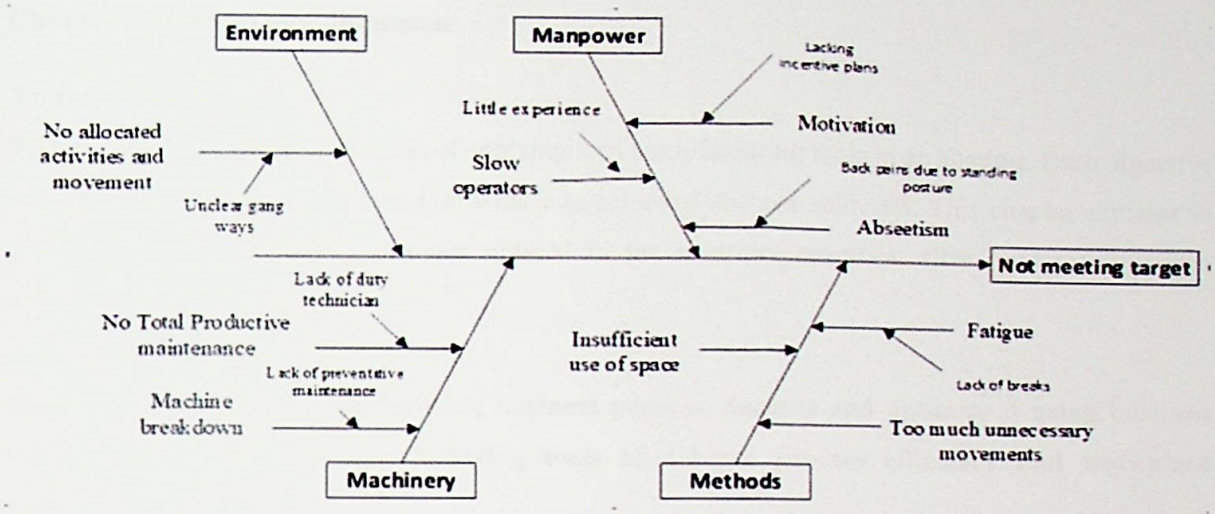


Figure 4-18: Cause and effect diagram for not meeting the production target

After work imbalance was identified, the researcher set with the management on the 12th May 2019 to show how the existing worker balance was and its effect. It was agreed to implement new work load allocations, with 4 operators being placed at the receiving gate, 6 operators placed at the offloading area, and lastly 16 operators at the production line, where the beast is caged for stunning up until is handed/ delivered to the customer.

4.6 Chapter conclusion

This chapter was outlining the implementation of lean tools in a beef abattoir. A roadmap was introduced as a guideline to lean implementation in a beef abattoir. Various forms, engagements, consultative meetings, training meetings, lean introduction awareness were made during lean implementation to engage employees on lean implementation initiative. Non-value adding activities such as waiting, high absenteeism due to back pains, a mixture of a carcass along the production line that delays the flow of work and disarrangement of workplace that leads to poor 5S, were noticed. These non-value adding activities were eliminated through the implementation of lean manufacturing tools such as 5S, identification of work standards, determining standards times and understanding the abattoirs value stream map to create customer value and value proposition. The chapter continues by highlighting lean tools implemented which are 5S, Root Cause Analysis, Value Stream Mapping, and work-study (i.e. motion and time study).

Chapter 5 : Results and discussion

5.0 Introduction

This chapter presents effectiveness of applying lean manufacturing tools in an abattoir. Each objective was analyzed and discussed based on what was achieved and not achieved. This chapter explains in detail the effectiveness and changes noticed in the abattoirs operation after implementing lean manufacturing tools.

Objective 1: To identify the existing business process, analyze and optimize it using business process tools and lean manufacturing tools to achieve process efficiency and workplace organization

When analyzing the existing process, it was found out that there are no policies/ standards that are in place, there are no systematic flow of operation, no monitoring records of production output, no waste reduction policies, no non-value adding activity elimination measures and long manufacturing lead time. It was found out that transferring of carcass within the production line leads to confusion that end up making operators to mix carcass. The cause and effect in Figure 5-1 was used to identify the root cause of missing carcass within production and the supply link which is the ultimate problem that the company wants to overcome. Problems were categorized in terms of methods, machinery, environment and manpower to address the root cause. Cause and effect diagram also known as fishbone analysis was conducted using cause enumeration application. This application was done by first defining the problem (for this case it was missing production carcass and bottlenecks within the company's supply link) comprising of six people (production manager, 3-line supervisors, 1 operator and a researcher). The major causes of the missing carcass within the abattoir were noted. After that, sub causes within each of the major causes were listed. Lastly, one cause was singled and analyzed. Singling out and analyzing each cause was done systematically so that the predominant cause is analyzed first. Systematically analyzing each cause helped to identify the root cause. The root cause of this problem was found to be a lack of tracking carcass within the production line and the supplier. During implementation, tagging carcass was introduced as a solution to avoid confusion/ mixing carcass in the production line. This carcass tagging addressed confusion and made sure that target is slaughtered with 50-51 beast in six hours with the same operators. The abattoir also made sure that the operations are being arranged in such a way that the tray for skinned heads is placed near the production

line to minimize waiting and transportation time. In below equations (1), (2) and (3) shows how improvements were calculated.

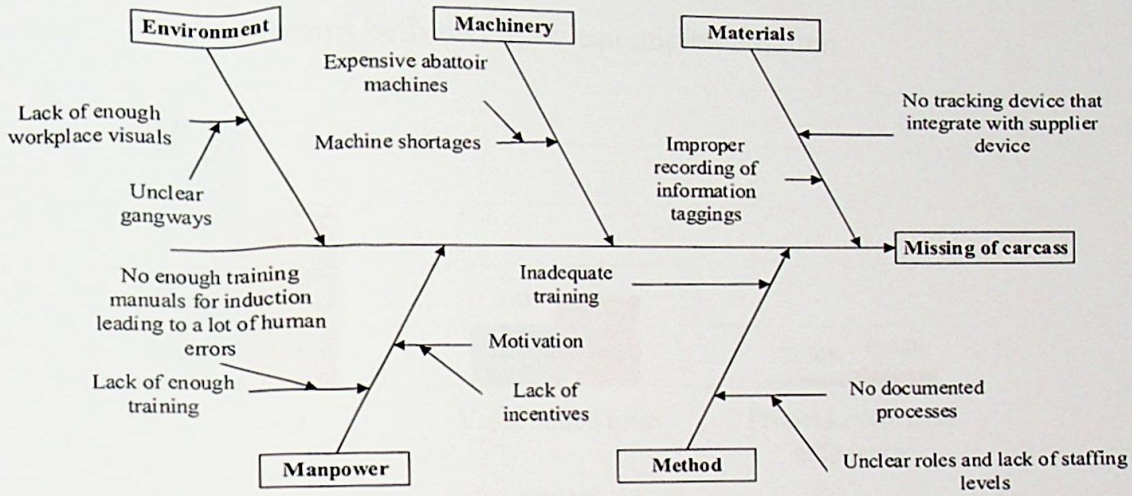


Figure 5-1: Cause and effect diagram for missing carcass within the production facility to the end user or customer

Equation 1: Improvements in terms of lead time = Before Production lead time – After Production lead time

$$= 9 \text{ hours} - 6 \text{ hours}$$

$$= 3 \text{ hours}$$

Equation 2: Value added time increment = value-added time after implementation –value-added time before implementation

$$= (2.46 * 60) - (2.03 * 60)$$

$$= 148 \text{ minutes} - 122 \text{ minutes}$$

$$= 26 \text{ minutes}$$

Equation 3: Improvements in Process Cycle Efficiency = $\frac{\textit{Change in cycle time}}{\textit{Original cycle time}} \times 100$

$$= \frac{PCE\ after - PCE\ before}{PCE\ before\ implementation} \times 100$$

$$= \frac{148 - 122\ min}{122\ min} \times 100$$

$$= 21.311475\%$$

$$\approx 21\ \%$$

Figure 5-2 illustrates improvements made after lean implementation through applying fishbone technique and analyzing the existing process to address waiting time identified during process mapping.

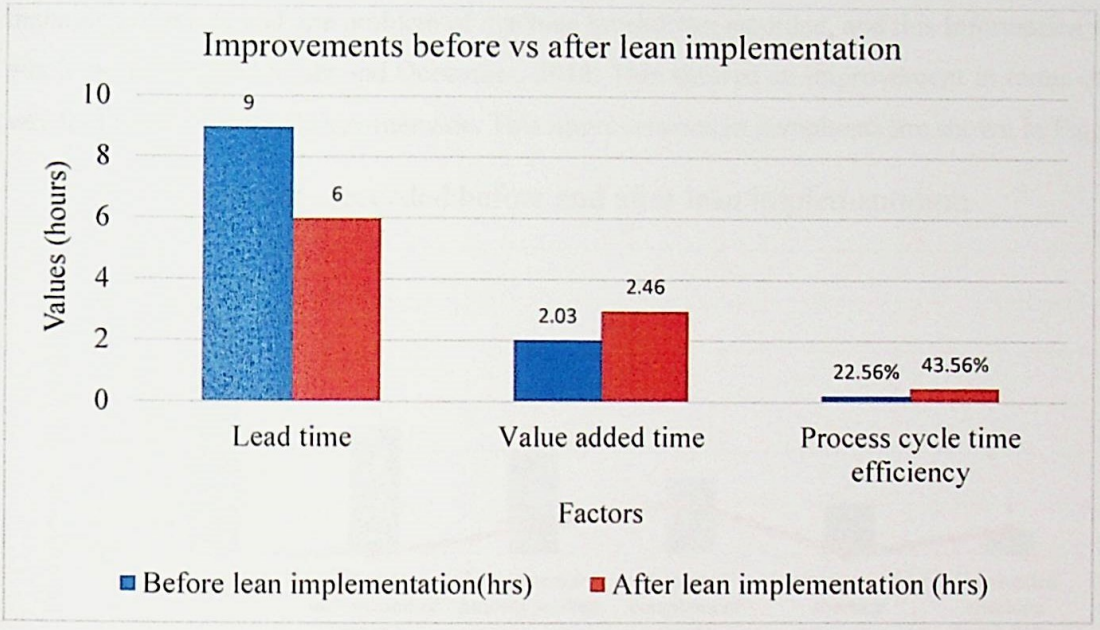


Figure 5-2: Improvements before vs. after lean implementation

In Figure 5-2, lead time was reduced from nine hours to six hours by reducing waiting time though introduction of straight product line when transporting carcass, eliminating transporting time of carcass (which used to be transported in batches), and saving transportation time by proper arrangement of trays (that hold skinned heads) in such a way that they are near the production line. Value adding time was increased by almost an hour after eliminating waiting/ queuing that was caused by batch transporting of carcass. Process cycle efficiency was increased by approximately 21% by making sure that transporting time that was exhausted by a holding tray that was placed far away from the production line is saved. This was an evidence after implementation of arranging holding tray for skinned heads in the production on September 2018. Complaints that were received were reduced within the abattoir. Below in Figure 5-3 shows how complaints reduced after non –value adding activities were removed within the process. This information was recorded on 3rd January 2019, as a follow up review for lean implementation in terms of process improvement. Before lean tools implementation, there were burning complaints that were given by participants of the questionnaire and interview. After some adding activies were eliminated during lean implementation by 5S and process mapping, there was no recorded complaint on confusion/ mixture/ missing carcass within the production line which was addressed by

introducing tagging of carcass as it moves wihin the production line, only one undocument process that involves waste management in the company was recorded, two complaints recorded on improper managing of waste and one problem of machine breakdown recorded, and this information was for the whole month of November and December, 2018. This showed an improvement in terms of customer satisfaction and abattoir's key mandate. This improvements in complaints are shown in Figure 5-3.

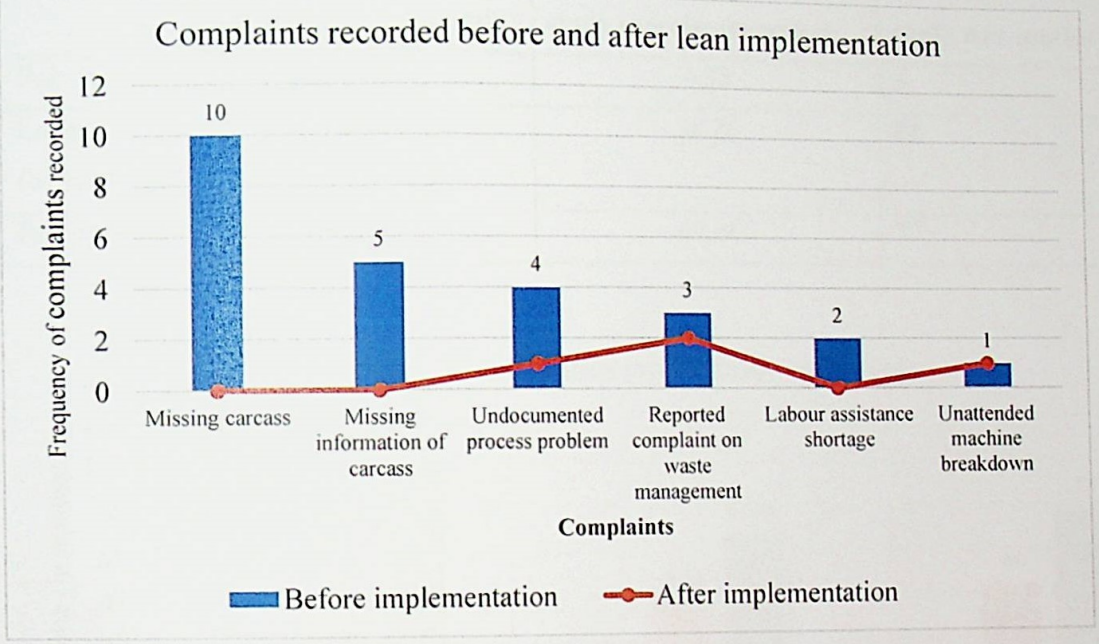


Figure 5-3:Complaints recorded before and after lean implementation

Work study and comparisons of times(time study) were provided to the company so that they can know how much time it takes for their processes and for continous improvement. With reference to time study conducted on the 12th April 2018 at the abattoir using stop watch and camera. Standard times were provided to the abattoir, to see how can Takt time be improved. Below in Table 5-1 and Figure 5-4 shows comparisons of times before and after time study was conducted (with standard times determined in terms of the value added time). This helped the abattoir to know how much times they take for their operation. Before time study was conducted, plant manager was interviewed to give estimated times for receiving, offloading and delivering five beast to customers. Below in Table 5-1 shows the times before and after time study was conducted. Figure 5-4, shows the comparisons of given estimated times of the plant manager, observed times by the researcher and the standard times determined by the researcher after incorporating PFD of 15% and a performance rating of 100%. From the analysis it shows that observed and standardized times are less than the given estimated times by the plant manager. Two authorizations were eliminated in the production line, thereby reducing delays it was

causing. This was noticed during reviews made on the 3rd January 2019, after those non-adding activities were eliminated.

Table 5-1: Comparison of times before and after lean implementation

Section	Given estimated times by plant manager(min)	Observed time during time study exercise (minutes)	Standardized time (after work study was conducted (minutes)
Receiving	16	4.35	5
Lairaging (offloading)	34	38.26	44
Production	100	67.06	77

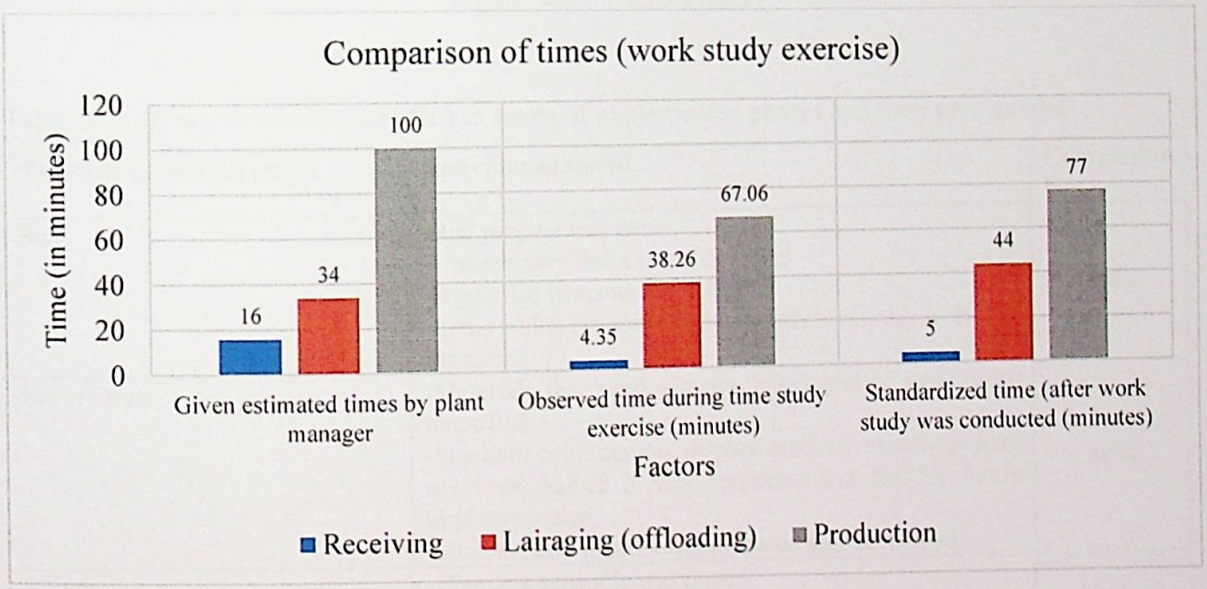


Figure 5-4:Comparison of times (work study exercise)

After the application of 5'S principles, based on the checklist used for 5'S audit, there were 45-48% average ratings of implementation. 5'S practices was not fully implemented because the abattoir was ready to fully implement all the phases. Some requirements were not accomplished such as creation of posters and labels due to the cry of budgets. In addition, it was recorded that arrangement of holding tray for skinned heads helped to reduce transportation time and idle time of about 20- 25 minutes of

the given 9 hours shift. Below in Figure 5-5 and Table 5-2 shows 5S achievements quantified in terms of implementation phases and explains those achievement activities in detail.

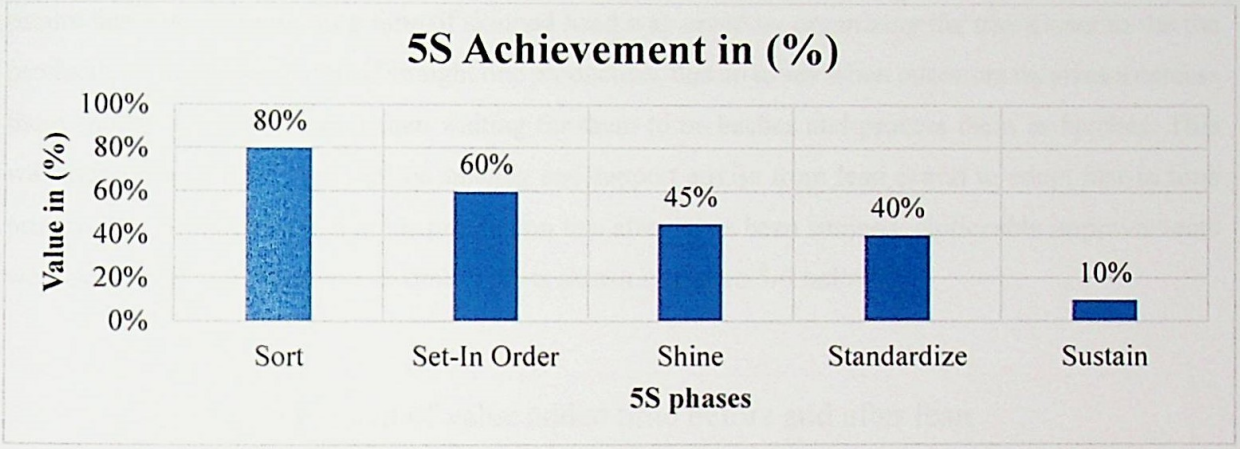


Figure 5-5: 5S achievement

Table 5-2: 5S achievement quantified in terms of implemented phases and their percentages

5S Implementation phase	Activities achieved	Completion %
Sort	-Red tagging was done -Unnecessary items were identified -Discarded items were red tagged -Items which are used weekly/hourly/ everyday were identified	80%
Set in Order	-Materials that need signage, labels and of stock were identified -Standard color coding, display cautions, messages were not done rather it was recommended for 5S future implementation -5S document manual was prepared and developed	60%
Shine	-Cleaning schedule was done -Inspection has been put in place -Area of cleaning storage and cleaning aids was done	45%
Standardize	-A 5S checklist was done for each area section -5S training was done -The periodic evaluation was not done but rather it was recommended for 5S future implementation	40%
Sustain	-5S council team was formed -5S was not fully implemented -There is no 5S good habit and discipline; rather it was emphasized in future 5S implementation.	10%

Objective 2: To carryout value stream mapping for the organization to find bottlenecks

Process cycle efficieny was calculated from the value added time in the value stream map, and it improved by almost 5% that was saved by eliminating transporting time of skinned heads in the production line. Transporting time of skinned head was saved by organizing the tray closer to the the production line. Introduction of straight line production, that so to say when operators receives a carcass there should process it, rather than waiting for them to be baches and process them as batches. This was incorporated after consultative meeting and support advise from lean expert to adopt just-in time processing of carcass as it is in the production line after it has been stunned. Noticeable improvements were seen with improvements in time. This is shown in Figure 5-6 below.

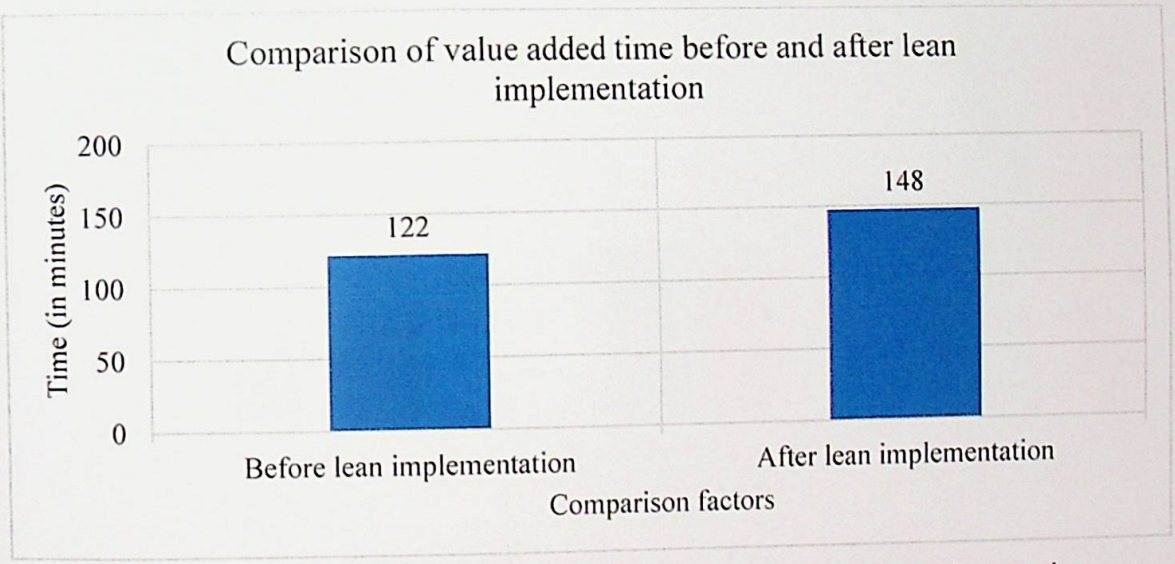


Figure 5-6: Comparison of value added time before and after lean implementation

After the computation of takt time, the 28 employees required to slaughter an average of 47 cattle in a day was reduced to 26 operators in a day. This was based on the recorded capacity completed by operators along the production line, after the implementation dated 23rd April 2019, the target output of 51 beasts per day were achieved by 17 operators in six hours. Figure 5-7 shows the manpower requirement before and after lean implementation. Proposed future state was established in consideration to work balance among operators, see Appendix O.

Reduction of manpower required in the production line and lairaging were cattles are offloaded were reduced by one manpower each to do the volume demanded. The excess manpower were transferred to

work in other areas. Only 26 operators were required for the new workload assigned, based on the takt time computed. Efficieny of production after implementation improved by almost 21%, this is also noticed during the process cycle efficiency when the value added time in the value chain is increased from 2.03 hours (122 minutes) to 148 minutes. Process cyle efficiency was calculated by subtrating value added time before lean implementation from the value added time after lean implementation, and then it is divided by the before cycle time.

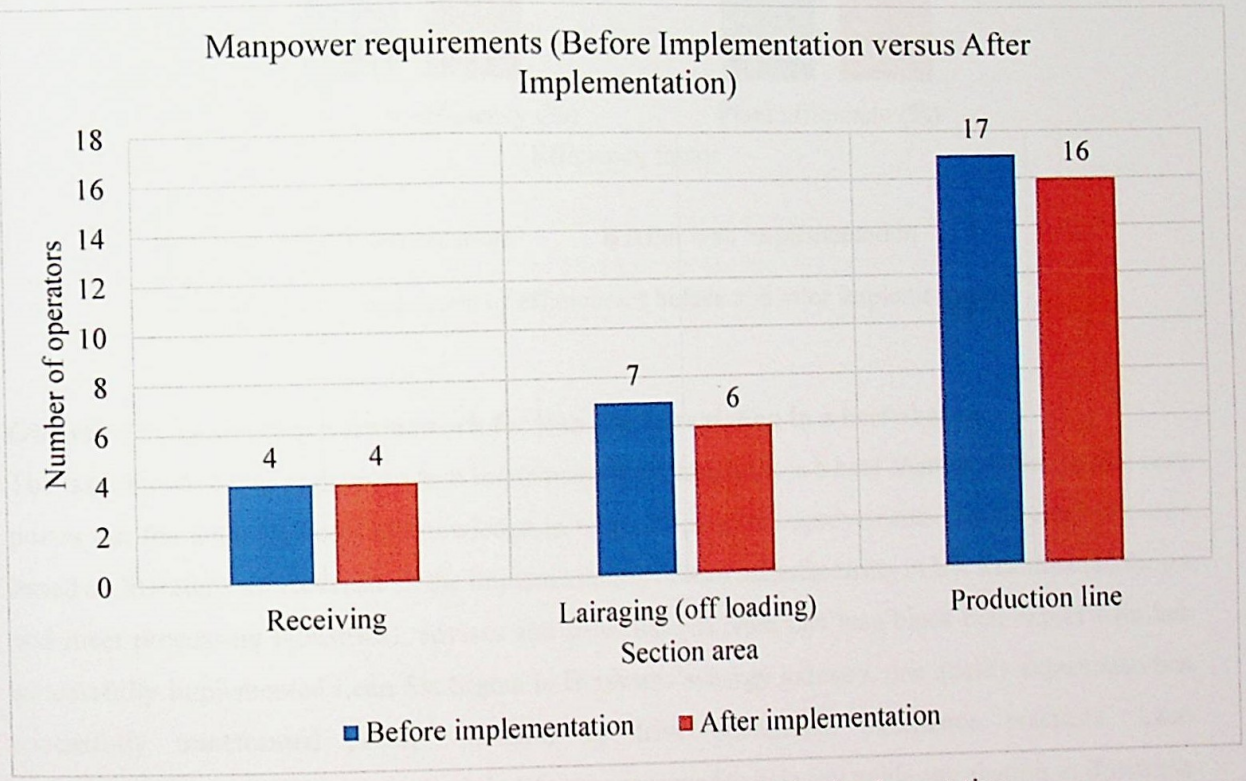


Figure 5-7: Manpower requirements before and after implementation

Overall plant efficiency increased by 21% from the 22 % that was existing before lean implementation. Thus making efficiency to be at 43.56%. This calculations were done in February 2019 after the process activity of two receipt of carcass authorization in the process was eliminated and replaced by emphasizing of carcass tagging as a way of identification and ordely arrangement of carcass in the production line. Comparisons of efficiencies before and after elimination of non-adding ativities is shown in Figure 5-8.

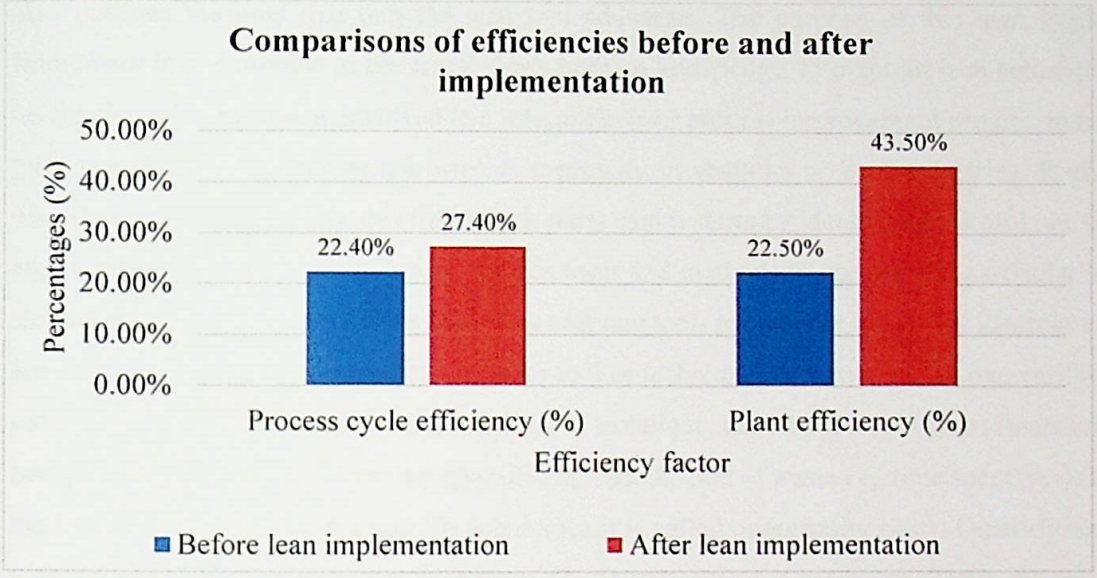


Figure 5-8:Comparisons of efficiencies before and after implementation

Objective 3: To develop a framework for lean implementation in a beef abattoir

The last objective was to propose lean implementation framework in a beef abattoir, which in this case points out the author's body of knowledge in terms of process improvements. This framework was based on literature sources read on the implementation of lean manufacturing in UK Red meat(abattoirs and meet processing industries), advises and consultations from one lean black belt expert who has successfully implemented Lean Six Sigma in Botswana'senergy industry, one quality expert who has succesfully transformed public's abattoir to drive operational excellence practices. Lean implementation framework in the beef abattoir was proposed to help and guide any abattoir in Botswana that will be interested to implement lean manufacturing tools in the future. Proposed lean implementation framework considers lean manufacturing tools that were implemented in the abattoir, lean tools supporting process improvement projects, and lean tools that are very crucial in the abattoirs operations. These lean tools and techniques are 5S(Good housekeeping), Waste management(7 lean waste), Total Productive Maintenance, Value Stream Maping, Pull Manufacturing and Work standardization.

Factors considered in this framework are interacting to each other in such a way that it specifies which tools to use, and support mentioned lean tools by outlining techniques that are used. The framework

also outlines the goal that that the lean tool addresses. The purpose of this lean implementation framework is to contibute to the researcher's body of knowledge, to pinpoint lean techniques that can be considered when one is involved in a lean projects or process improvement project, to help provide guidance in lean implementation projects especially in abattoirs or beef industries. It gives readers direction by guiding on how this framework starts, and it starts by identifying the tool one is willing to apply, then the second row shows you which tools and methods to use for that particular lean tool or technique, then the third row shows you data anlysing tools to consider, forth row illustrates what goals are you trying to achieve with that particular tool or technique, fifth row shows one verifying tools to measure the output of that particular lean tool or technique, then the last row gives financial metric for beneficial tracking. Lean wastes are quantifed against the cost of waste i.e, time spent on waiting versus the loss made out of that waiting (in economics it is called opportunity cost). Quantifying lean tools with financial metrics helps to do Return On Investments for reporting. These financials can be addressed through creating metrics that is measured in the abattoirs dashboards for operation decision making. This metrics are not only limited to cost of waste reduction, they also consider performance assessment and lean cost savings. This framework was approved to be a trial framework after critiqued by three lean experts, one being lean expect in Botswana Power Corporation (energy industry), the second one being continuous improvement expert at Morupule Coal Mine (mining sector) and the third one being lean consultant expert of Botswana Private Abattoir who was engaged in consulting the abattoir on beef stratergic tansformation. The framework is shown in Figure 5-9.

5.1 Discussion

This research was overwhelming and interesting because it was the first time the company collaborate on research that involves implementation of lean tools for strengthening process improvement. Formalization of research was done through proposals and management request for buy in. The proposal was done for both at school and in the company. It was very essential to write a proposal because it allowed both parties to understand the benefits of the research. Consultative meetings, discussions and presentation were also other forms that were used in formalizing the start of the research. Issues of concern such an un-optimized process, no standardized working procedures, no documented processes, long manufacturing lead times and improper housekeeping which was leading to a cluttered environment in the workplace and posing safety hazards to employees were discovered in the abattoir. Lean tools were explored to eliminate these problems that the abattoir was experiencing.

Lean tools and techniques that were applied are root cause analysis (fishbone diagram) to find bottlenecks within the abattoir, 5S for workplace organization, value stream mapping for identifying value adding and non-value adding within the production system, time-study to determine standard times for production operations and for better work methods and process mapping for process flow mapping.

The research was successfully completed with process flow mapped, standard times determined, 5S partially applied and elimination of non-value adding activities. Data was collected through interviews, questionnaires and the collected data was presented in Pareto Graph, Microsoft Visio and bar graphs. Recommendations, future directions were submitted to the case study company and BIUST so as to improve in terms of research collaborations.

The researcher drafted operating procedures using the template, see Appendix N which was later reviewed by the management on the 20th April 2019. With reference to a consultative meeting on the 19th Many 2019, drafted operating procedures were approved for use by the manager, director and three supervisors as a standard way of doing work in the abattoir. Table 5-3 shows the status of 5S implementation, 5S was partially implemented and the last two S (which are Standardize and Sustain were not implemented) due to the fact that the company was not ready to implement them, and the company did not have enough skilled personnel and resources to implement the last phases. The company was provided with 5S training manual drafted to use as a reference during 5S awareness and trainings, See Appendix F.

Table 5-3: 5S implementation summary

Problem issue	Lean tools used	Description	Status quo	Challenges
Insufficient workplace improvements	5S audit checklist 5S team council Training Facility layout design	-There was no signage, unlabeled equipment, floor marking, improper display and storage of material handling equipment.	-5S implementation was partial done. Facility layout design was drawn to show areas of improvements or what they need to prioritize when they have enough budgets to complete 5S implementation	-Some suggestions were discarded -Delay in response from the management

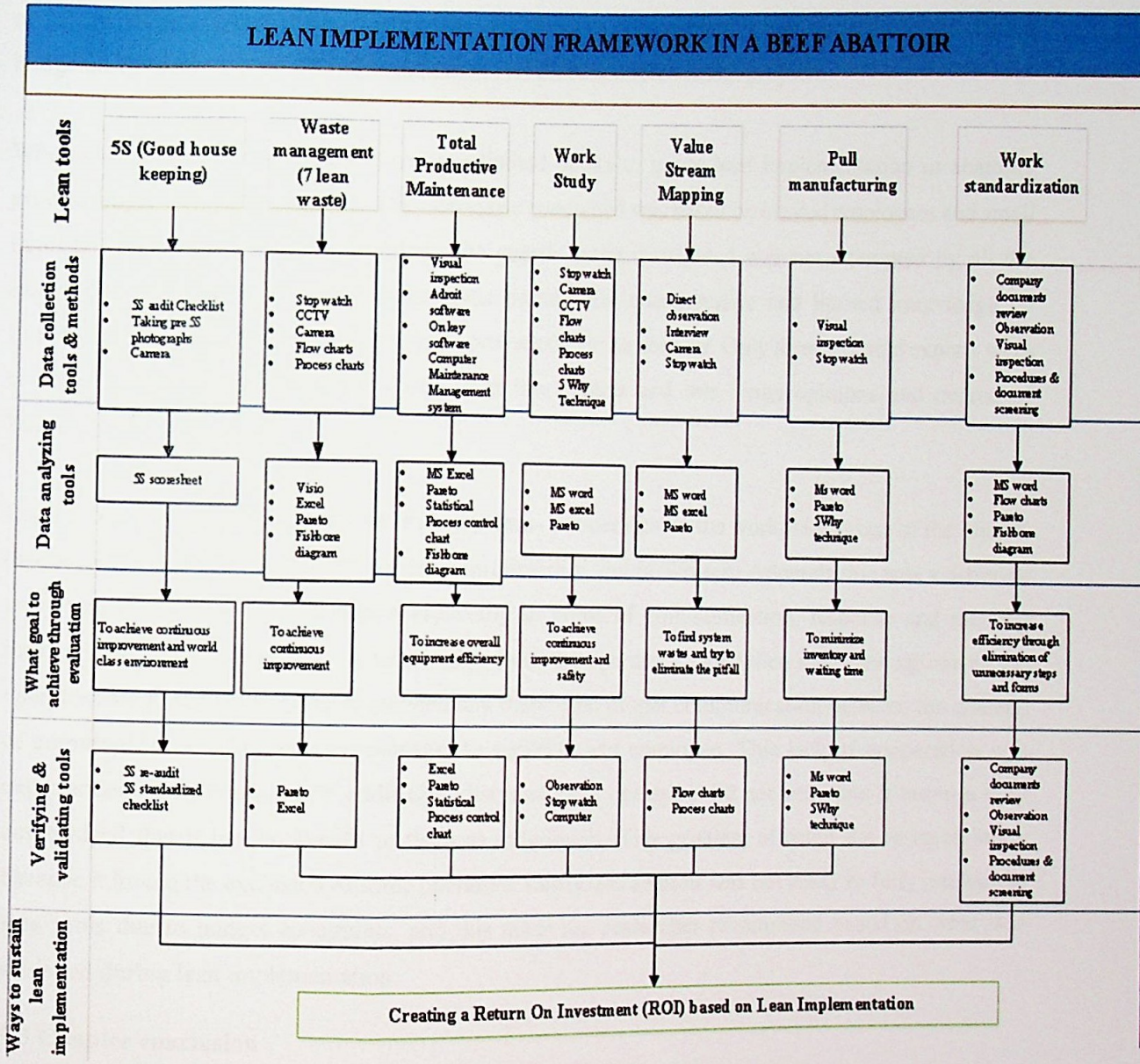


Figure 5-9: Proposed lean implementation framework in a beef abattoir

5.2 Research limitations

Case Study Company not ready to fully implement lean manufacturing tools -The abattoir was not ready to fully implement 5S practices. This made it difficult to see and quantify the benefits of 5S practices in an abattoir. This affected the output of the research as I had to report on only the 3 practices

out of the 5S practices that were invented by the Japanese. The researcher also noticed that the abattoir budgeted little amount on 5S implementation and process improvement projects.

When conducting this research, there was limited books to guide lean implementation in abattoirs process improvement in abattoirs. The interviews conducted was based on limited employees and small number of interviewees is a limitation. The questionnaire distributed was not attempted by all the sampled employees and the employees who partake the questionnaire had limited knowledge on implementation of lean tools and process improvements in an abattoir. Only three external experts were consulted during this lean implementation at the abattoir and this limits opinions and degree of knowledge.

Lack of cooperation from some of the operators- Cooperation in the workplace is one of the aspects that drive company's goals in achieving its profitability, but in Western Apparels this was a different story when it comes to cooperation especially in terms of communication, response and meeting interactions. There was a lack of cooperation from the operator's side when interviewing one of the operators about the situation he responded that there is no proper communication between the channel of communication of production manager-to supervisor-to employee. This lack of cooperation was experienced when issuing a 5S audit checklist, and most operators did not complete it because they emphasized that it has no benefit to them as individuals. This problem affected the research study because it forced the exclusion of some operators. Lastly, the abattoir was not ready to fully implement lean tools due to budget constraints, and this made the researcher recommend based on what was achieved during lean implementation.

5.3 Chapter conclusion

The main findings of this research are summed in this chapter and it shows that the company has a potential of improvement in terms of good housekeeping, value adding time activities and cycle time improvements. Results of all objectives of the research were done, analyzed and discussed on the merit of trying to pinpoint the effectiveness of lean manufacturing tools. Moreover, research limitations were also noted to give readers an insight on the limitation of these research.

Chapter 6 : Conclusion & recommendation

The main contributions of these research were to strengthen abattoirs processes through use of lean manufacturing tools. It is very hard in abattoirs to find bottlenecks especially if there are no standard process flow that guides the way the production or value flows. Awareness of abattoir's standardized production flow and process activity time can help to meet production target and improve productivity. The research study was completed well; lean manufacturing tools such as value stream mapping, root-cause analyses technique, and 5S were used for implementation at Botswana Private Abattoir. Non-value adding activities such as waiting and transporting time were identified within the process flow value stream map, respectively. Two authorizations that occur within the production line that is done by the operator when the operator request authorizations of inspecting the carcass and request another authorization for inspecting skinned heads was identified in the process flow as these two activities creates waiting in the production line amount to about 24-30 minutes per beast and this activities forced to the abattoir to use batch processing (which was creating a lot of waiting time). Mixing of carcass was also another bottleneck that was identified during the value stream map. Absenteeism and not meeting target were issues that were raised by the interviewees and employees who attempted the questionnaire conducted. Improper housekeeping was given by survey respondents through plant tour conducted. Including change management awareness right from the beginning is fundamental to avoid instances when the case study is no longer interested in implementation because they anticipated quick benefits which won't be the case.

With implementation of value stream mapping, the abattoir managed to see the waste that exist within the production like misallocation of tasks. Mapping the existing process flow, highlighted to the abattoirs management that there are too many authorizations that need to be simultaneously combined into one control activity where necessary, to save time. Value stream mapping helped to determine production output per hour, and to eliminate waiting by introducing straight line production which was later adopted by the abattoir. 5S implementation resulted in better arrangement of tools and equipment by rearranging skin holding tray (which was placed far away from the production line) and this rearrangement saved approximately 24 minutes per carcass.

6.1 Research deliverables and achievements

Research aims was delivered with existing process analyzed using process flow tools called Microsoft Visio, and too many authorizations identified as activities that created waiting within the production

line were eliminated which yielded time saving of about 24-30 minutes. Process activities were optimized by with an improvement of added time with 26 minutes and a process efficiency of 21%. This was done after two authorization that used to take place one after another was eliminated by making it one activity within the production flow. Workplace organization (5S practice) was partially implemented with arrangement of some tools such as skinned heads tray to be close to the production line by saving transporting time of about 10 minutes and this information was recorded on the 23rd May 2019, after 5S implementation reviews. Value stream map objective was delivered as the researcher managed to find the bottlenecks within the production line such as absenteeism, more delays due to carcass inspected in batches. Tagging of carcass in the production line solved the issue of carcass ending up being mixed up in the production line thus saving time such as delays. The lean introduction was done in the company through campaigns, training, meetings, and consultation with all management staffs. The support of the management was amazing and overwhelming thus allowing smooth introduction of lean in the abattoir, actual implementation and effectiveness of these lean tools implemented. Recommendation and suggestions were made to the company as it was key for research deliverables. Future directions were also provided to the abattoir. Along with the research, two of the conference papers were published.

6.2 Future directions and recommendations

Future research is to write more papers based on 5S implementation, value stream mapping and process mapping that the author did in abattoirs. Another future research is to examine, and test lean implementation framework developed by the author. Valuations of this framework will be used to measure their impact on production efficiency, process improvement and productivity. Future research is also to consider making awareness and trainings on change management before any research questionnaire is distributed or doing any conceptual framework implementation, because there was a lot of change resistance and abattoir's employees were not participative in the survey conducted. 5S practices were partial implemented. The other future research the author is suggesting is to re-valuate this conceptual framework of 5S practices by fully implementing all the five phases since the 5S practices was partially implemented due to the abattoirs limited budget, and this will help the author to examine its benefits in an abattoir.

6.3 Recommendations to the abattoir

Not all 5S implementation was completed since the research company was not ready. Suggestions and recommendations were made.

6.3.1 5S recommendations

As 5S was not fully implemented there was a need to make a recommendation based on the progress of 5S thus far and based on what was achieved.

i. Recommendations is made to the abattoir to label, mark, indicate walkways and partition all cabinets, racks, desks, machines and workstations – All cabinets, racks, desks, production machines, and workstations should be labelled and partitioned, so that it is clear where things are, and where things should be returned to.

Proposed design layout to address 5S and safe workplace organisation in the abattoir

A proposed layout was designed to pinpoint and highlight areas that can help the beef abattoir whenever to address good and safe workplace organisation. Proposed layout was made to address current observation that were in the company's existed design layout. This recommendations are made in the proposed design layout illustrated in Figure 6-1. It was recommended that the study beef abattoir should;

i. Demarcate areas where cars and delivery trucks are parked, walkways, pallets, and trolleys are stored, transporting and material handling. This demarcations must be neatly kept and this areas are shown in the designed layout by key point 1 and represented with a brown colour on the design.

ii. Update visual displays on 5S practices; stickers, tape marks are updated and removing old displays. Indications on places that needs sign panels are shown on the proposed layout. Proposed layout highlights this areas that needs needs visuals and indicated by key point 2.

iii. Indicate storage of tools with labels and signs. All the offices, store rooms, kitchen, security gate offices should clearly store their tools with sign panels and labelling. Recommendations were made for all cabinets, shelves, desks and workstations to be labelled and partitioned, so that it can be clear where things are, where things should be returned to for easy retrival. Areas that needs those sign panels, tool labellings and partitionings are shown by key point 4 with a blue color.

iv. Comply with safety regulations in terms of emergency exists, and no foreign objects in electrical switchboards, ashtrays and indication of safety risk areas. Areas that needs safety risk assessment and emergency exits are shown by key point 5 with a yellow color.

v. Electrical switches, cables and breakers should be insulated and clearly indicated to avoid electric shocks. It was recommended that areas where there are cables and electrical switches should be indicative of voltage they carry. Areas where this cables should be insulated and clearly indicated are shown by key point 8 with an accent red color.

vi. Use of septic tanks for storage of waste since it was found that the abattoir just discharge abattoir waste running through streams and ponds thereby giving rise to offensive odour and leading to eutrophication. Therefore by using septic tank it would allow to recycle the water and even treat the wastewater for other uses, rather than polluting the environment. Area which was suggested for this building of this tanks is shown by key point 9 with accent purple color.

6.3.2 Process documentation

Recommendation were made for documented processes to be reviewed in about 3-6 months depending on the changes that would have been made in the process flow.

6.3.3 General recommendations in the abattoir's operation

i. Workload balancing

Work should be divided in such a way that each operator should get an equal workload. This will motivate operators in their work content which results in improved productivity. Work balancing can be achieved through operator's reassignment. Each operator should, therefore, be trained for at least three to four operations of their respective work cells. This will help to rotate operators between different operations.

ii . Improving material handling of skinned heads through the use of rollers

Carcass heads are carried by a orker one by one because they are heavy. And it takes about twenty minutes to move back and forth to return to the production after transporting skinned head to the holding tray. It is proposed that the roller conveyor should be installed beneath the productin rail where the heads will be moved to where they are systematically arranged, tagged, inspected and counted.

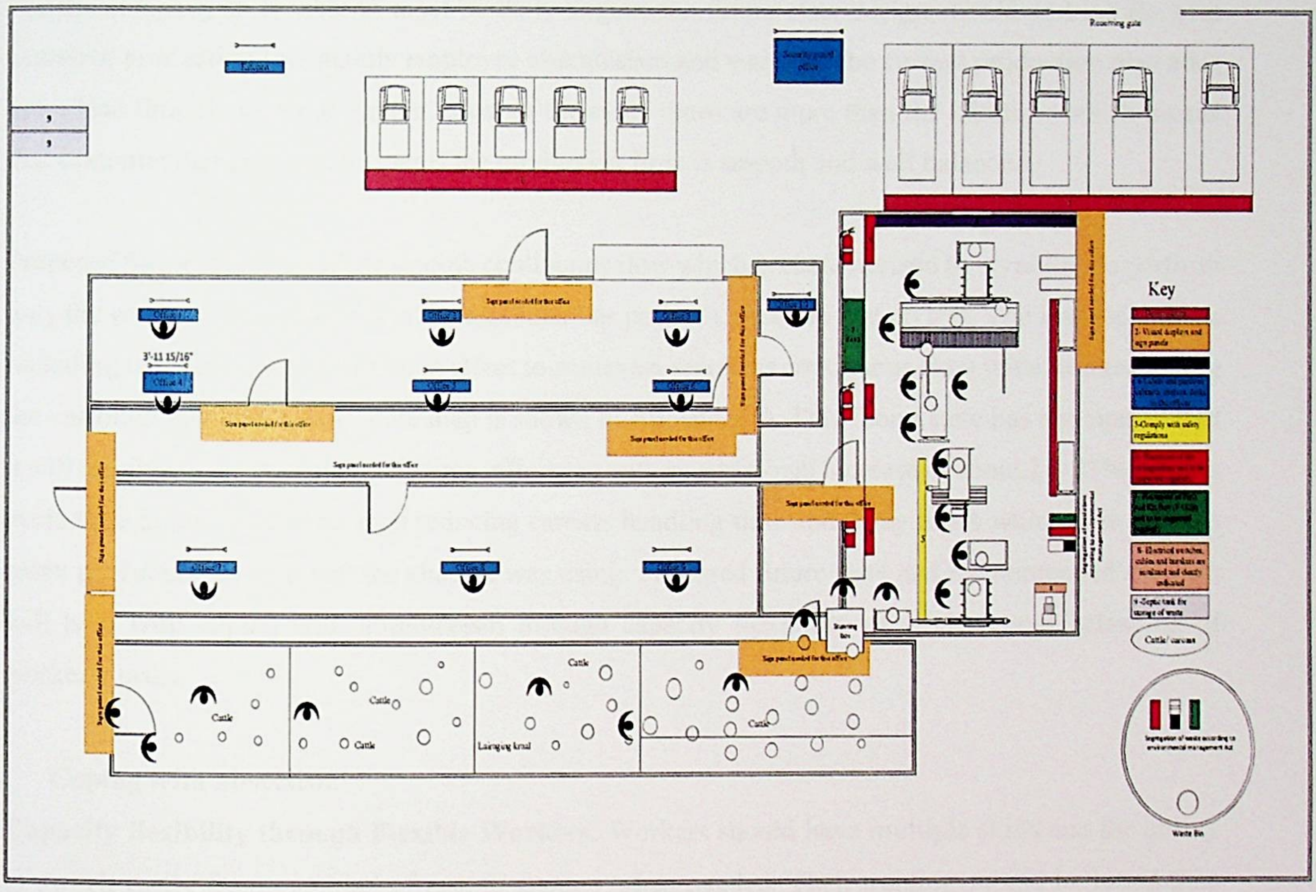


Figure 6-1: Proposed design layout to address safe workplace organisation

6.3.4 Value stream mapping

Most non-value adding activities were partially eliminated and not further examined since the abattoir could not adopt some suggestion. These recommendations highlight an anticipated reduction of cycle lead time of 52 cattle's in 6 hours as opposed to 47 cattle's in 9 hours, and this proposed recommendation also anticipate an improvement of about 20 – 23% cycle time improvements, reduction in lead time and Takt time improvement. This lead time is anticipated to achieve lead time improvement through elimination of waiting and introducing one smooth flow as opposed to the batch production that was used by the abattoir, see Appendix O.

Future state design(value stream map)

For the company to be able to meet its daily targets, the future state design should address the root causes of production loss mainly employee absenteeism and waiting. The current production plan adds more lead time to the value stream. Most of the cycle times are more than the takt time which means that customer demands can be met if the production flow is smooth and well balanced.

Proposed future state will allow smooth continuous flow which is characterized by its ability to perform only the work that is needed when the customer has pulled it, no more and no less. The lean techniques including takt time and 5S will be in effect to achieve a seamless continuous flow without interrupting the customer demand. Future state map is shown in Appendix O. This future state has anticipated that it will feasible to improve the cycle time efficiency with an additional increase of about 21- 23% process cycle time improvement, through reducing carcass handling time and delay times which was due to a batch production system that the abattoir was using. Proposed future state and recommended solution will help with coping with absenteeism through capacity flexibility of workers and balancing of worker's tasks.

i. Coping with abseetism

Capacity flexibility through Flexible Workers: Workers should have multiple skills and the ability to switch easily from one kind of task to another when needed. Their training should be broad than specialized in just one competency and need managers and staff support to facilitate quick changes in their work assignments.

ii. Worker balance chart

Future worker balance chart is a visual display of work elements, times and workers at each location to show improvement opportunities in relation to value stream cycle time and takt time. Future worker balance chart was made to review cycle times and personnel assignments as shown in Figure 6-2. The design of the future state will highly regard workload balancing in order to achieve flow among the operators. The distribution of workers among the processes, i.e. gate receiving section, lair aging and production shop floor processes in the ratio of 1:1:2 and operators achieves flow through minimizing idle time and few queues at bottleneck stations. If absenteeism persists, production plan can always balance by redistributing the available worker using this ratio provided they are multi skilled as

suggested in the training plan. The future value stream design will use the cycle times determined in the future worker balance chart.

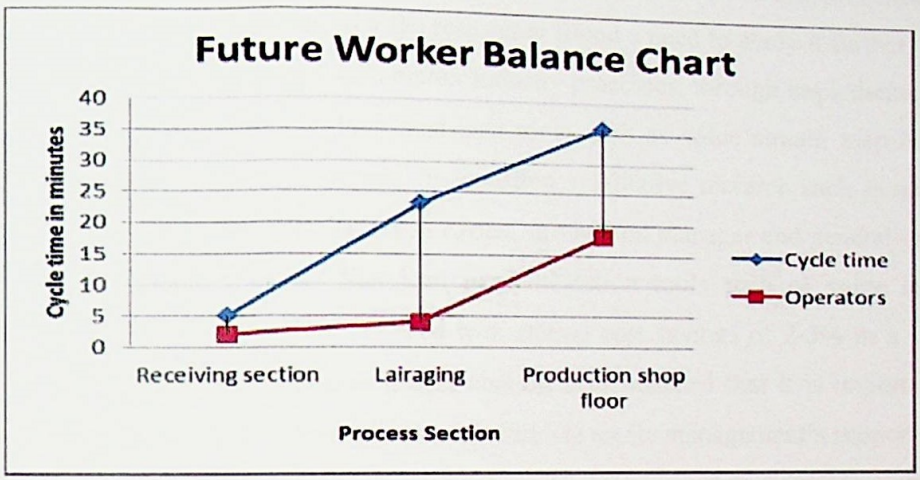


Figure 6-2: Future worker balance chart

Production start will be initiated by downstream processes and they will pull the products from their preceding process as illustrated by the arrows in the future design value stream map in Appendix O. As the next process pulls the output from the process they follow, queues will be eliminated. These future designs start by producing and slaughtering exactly 52 cattle in six hours per day. The work in process can delay up to a maximum of 5 minutes until it is pulled by the next process. Future state design is shown in Appendix O.

Successful implementation of the future value stream map will accomplish continuous flow of work, control of upstream work, training and communication. The notable improvement upon the implementation of the future design is shown in Table 6-1 below which include lead time, value percentage of the time, process cycle efficiency and percentage of meat quality inspection screen.

Table 6-1: Current State vs. Future State

	Current State	**Future State**	**Projected % Improvement**
Total lead time	9 hours	6 hours	33.33 %
Value-added time	2.03 hours	2.99 hours	47.78 %
Value Percentage of time (value creating time of total time)	22.56 %	17.67 %	21.94 %

6.4 Summary of the research

Process improvement in abattoirs is very important as it allows clear flow of work, process consistency and standardization of work, which is why the researcher found a need to study it further. The aim of this research included; strengthening local abattoir industry processes; through implementation of lean tools. This research question was, i) how best lean tools such as value stream map can assist in strengthening abattoir processes. To answer this question, qualitative research such as questionnaire survey and interviews with one consultant lean expert, production manager and general were used as research methods. Chapter 3 shows that lean implementation tools such as value stream were implemented in abattoirs and this was revealed with stating cost savings of 2-3% in a value chain. Analysis of lean tools implementation in a beef abattoir also revealed that it is important to make awareness, conduct lean thinking introductions in abattoirs to create management's support and buy in. Chapter 4 shows illustration before lean implementation of lean tools and the actual implementation of lean tools as process flow charts, 5S, value stream mapping and Takt-time, Root Cause Analysis and time study. These tools were implemented after production inefficiencies such as lead time of slaughtering 40-45 cattle in 9 hours, confusion within the production process that lead to carcass mixture, non –value adding activities such as transporting time and disorganized workplace. Chapter 5 discusses the effectiveness of lean implementation tools in a beef abattoir and shows the results of what was achieve through lean implementation. Effectiveness of eliminating non –value adding of transporting skinned head in the production line was achieved by placing tray near the production line, hence saving 24 minutes of time. Documented process flow was discussed with abattoirs management to be used as the standardized way of doing work for SOP's. Chapter 6 concludes the research and provide recommendations based on what was achieved. Proposed framework for lean implementation in abattoirs was developed to guide future research for lean implementation in abattoirs. Not all lean tools were completely implemented such as 5S (only first 3S was done, which is Sort, Set in Order and Shine), future state map and proposed value stream were not evaluated for improvements and the researcher proposed a lean implementation framework in a beef abattoir.

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Appendices

Appendix A: Interview questions



PURPOSE: To investigate the root causes concerning production operation and supply chain management

DIRECTED TO: Botswana Private Abattoir staff and management

PREPARED BY: Babedi Kufigwa

DATE: 28 March 2018

SAMPLE QUESTIONAAIRE ON PRODUCTION AND SUPPLY CHAIN OPERATION

1. What is your production lead times and cycle times, giving them in time per output and how do you record them?
2. What are the challenges you are facing in your production operation, classifying them in terms of processes, people, technology and governance?
3. What is the demand, supply network, delivery times and production target in a day?
4. What is the abattoirs production output in a day, production duration and design capacity?
5. The challenges and bottlenecks you are facing in your supply, demand, production, input, process and output
6. How is the workplace organization and safety?
7. How do you deal with the management of the main wastes of the manure and effluent (liquid waste or sewage discharged from cattle, or waste removal)?
8. Do your company have standard operating procedures within the production line?
9. How are your drainage systems, does it include sedimentation tank or basin and effluent holding pond?

Appendix B: Questionnaire



PURPOSE: To investigate the root causes concerning production operation and supply chain management

DIRECTED TO: Botswana Private Abattoir staff and management

PREPARED BY: Babedi Kufigwa

DATE: 28 March 2018

Questions	Answers				
	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
Does the abattoir experience more complaints due to unclear flow of work					
Does the abattoir experience more complaints due to service delivery					
Does the abattoir experience more complaints due to the abattoir's systems used for production					
Does the abattoir have good workplace organization					
Are you any principle that guide good housekeeping in the abattoir					
Do you believe that the abattoir meets its production lead time on daily basis					
Do you believe there is a clear flow of work within the abattoir					
Do you know any techniques that the abattoir uses to address any inefficiencies that exists					
Do you know your value proposition as an abattoir that operate in Botswana					
Do you know any form of waste that the abattoir experiences in its production operation					

Appendix C: 5S Audit checklist

5S Audit Form

NAME: _____ **DATE:** _____ **TEAM:** _____

For each statement, check the score that best represents the 5S level for each item in each category.

Total score for each category and then add category totals.

SORT **Sort out necessary & unnecessary items. The items deemed unnecessary and not being used should be removed from the area (incl. General area, workstations, personal storage areas, desk drawers, filing cabinets, PC electronic files, safe)**	**Unacceptable** *No evidence shown*	**Poor** *Only evident here and there*	**Good** *Applied and evident in most areas*	**Excellent** *Thoroughly evident and applied to all areas*	**World Class** *Continuously looking for ways to make even more improvements*
1. Items/supplies on surfaces have been sorted, separating needed (used frequently) from unneeded (used infrequently or not at all).	1	2	3	4*	5
	Details:				
2. Items/supplies in bookcases or on shelves have been sorted, separating needed from unneeded (available electronically or not needed at location).	1	2	3*	4	5
	Details:				
3. Items in cupboards or drawers, including desk and file drawers, have been sorted, separating needed from unneeded (available electronically or not needed at location).	1	2	3*	4	5
	Details:				
4. Items on floors have been sorted, separating needed from unneeded eliminating floor piles and all cords are safely contained.	1	2	3*	4	5
	Details:				
5. Needed items (in cupboards, drawers, bookshelves, on surfaces, or floors) have been placed at the closest location to where they are used the most to minimize the waste of motion.	1	2	3*	4	5
	Details:				
6. Unneeded items have been removed from the work area.	1	2	3	4*	5
	Details:				
7. Work agreements for the above are documented and all staff know where to find the agreements.	1	2	3	4*	5
	Details				
Total Score					24

SET IN ORDER **A place for everything and everything in its place so it should be easy to find**	**Unacceptable**	**Poor**	**Good**	**Excellent**	**World Class**
8. Locations of needed items are labeled and items are in correct locations.	1	2	3	4*	5
	Details:				
9. Required quantities for needed items are determined (par levels), including items in desk drawers and in bookshelves.	1	2	3	4*	5
	Details:				
10. Locations for movable items are labeled, and items are placed in correct locations (white board/ laminated card/label on wall can be used).	1	2	3	4*	5
	Details:				
11. Visual controls and indicators are established including: Posted map of area, including individual room maps.	1	2	3*	4	5
	Details:				
12. There are Kanbans for re-order (if used by group agreement).	1	2	3	4*	5
	Details:				
13. There is Labeling indicating contents of drawers and cupboards (a new person should be able to locate without assistance).	1	2	3	4*	5
	Details:				
Total Score					23

SHINE **Keep work area clean and ready to use. Inspect regularly to ensure sort and set in order are maintained.**	**Unacceptable**	**Poor**	**Good**	**Excellent**	**World Class**
14. Work areas and equipment are stocked and organized on a consistent basis according to 5S agreements and schedules.	1	2	3	4*	5
	Details:				
15. Members of the work group follow 5S agreements on a daily basis.	1	2	3*	4	5
	Details:				
16. Sources and frequency of 5S problems are documented as part of routine work by all staff.	1	2	3*	4	5
	Details:				
17. Surfaces are cleaned and clear of dust and debris.	1	2	3*	4	5
	Details:				
18. Checklists are utilized to identify ongoing Shine duties and the status of these are up-to-date.	1	2	3*	4	5
	Details:				
Total Score					16

STANDARDIZE **Maintain the first three S's and have an awareness of improving neatness.**	**Unacceptable**	**Poor**	**Good**	**Excellent**	**World Class**
19. There is a 5S agreement in place and all employees know where it is located.	1	2	3*	4	5
	Details:				
20. Leadership can explain why 5S is important.	1	2	3*	4	5
	Details:				
21. All staff can explain the importance of 5S.	1	2	3*	4	5
	Details:				
22. There is a standard process for training and orienting new staff to the 5S system.	1	2	3*	4	5
	Details:				
23. There is a process in place to ensure unnecessary items do not "creep" back into the work area.	1	2	3*	4	5
	Details:				
Total Score					15

SUSTAIN **The 5S Discipline is embedded so that it becomes a way of life. 5S is no longer an event but routine.**	**Unacceptable**	**Poor**	**Good**	**Excellent**	**World Class**
24. 5S plans and action updates are clearly displayed and current.	1	2	3*	4	5
	Details:				
25. Success stories are displayed and confirmed for improvement.	1	2	3*	4	5
	Details:				
26. Staff 5S roles are clearly identified.	1	2	3*	4	5
	Details:				
27. Department audits and subsequent improvement plans are displayed and current.	1*	2	3	4	5
	Details:				
28. Are work instructions and procedures available in the workplace regularly reviewed/kept up to date?	1*	2	3	4	5
	Details:				
29. Are display boards, activity charts, notice boards, etc. up to date and regularly checked?	1*	2	3	4	5
	Details:				
Total Score					12

Total the category scores to find your 5S level:

Level 1: 1-26

Level 2: 27-52

Level 3: 53 - 78

Level 4: 79 - 104

Level 5: 105 - 130

Appendix D: Waste identification form

Waste	Category	Action	Comments

REFERENCE

Unnecessary Items	Label	Action	Label
Items having no value and easy to dispose	1	Throw away immediately	A
Items having some sale value	2		B
Items having no value and their disposal is costly	3	Work out less costly way for disposal	C

Comments section: if the item cannot be assigned the assigned categories and can be labeled as one of the following:

- Excess materials
- Infrequently used tools
- Defective materials
- Personal items
- Outdated information

Appendix E: 5S Proposing letter for forming 5S team Council

Private Bag 16
BIUST
Palapye

26 March 2018

Botswana Private Abattoir
Palapye

Dear Sir/Madam

RE: PROPOSAL TO FORM 5S (JAPANESE LEAN TOOL) TEAM COUNCIL

It is with great enthusiasm that I forward my application to you in proposing to form a 5S team council.

5S is a lean technique that uses the 5S (sort, set in order, shine, standardize and sustain) to organize and maintain a neat and clean facility. For the 5S system to be successful: commitment, participation and involvement of everyone is vital and most importantly a strong visible support from the top management. The 5S council is formed to enhance the total participation at all levels of employees, to develop continuous improvement culture and best performance spirit in the teams. I am proposing to have a 5S team council which comprises of the production manager, (Mr. Mmelesi), the director, (Mr Phampa) and the researcher, (Mr Babedi), since they are in a top management level and they have a better understanding how will these tools enhance the company's safety and workplace welfare.

I hope my request will be highly considered. Thank you

Yours Faithfully

Babedi Kufigwa

CELL: 74736032/ 76789024 / 71833093

Appendix F: 5S Training Manual document to be used for 5S training awareness

COMPANY: Botswana Private Abattoir 5s training manual

PURPOSE: To provide knowledge and issues of 5s to the management

DURATION: 30 minutes

DATE: To be announced

PREPARED BY: Babedi Kufigwa

ATTENDANCEES: Production manager, director, supervisors & staff

GOOD HOUSEKEEPING TECHNIQUES FOR ENHANCING PRODUCTIVITY, QUALITY AND SAFETY AT THE WORKPLACE

1. What is 5S all about?

5S is amongst the first and fundamental steps implemented by an enterprise towards the path of implementing Total Quality Management and continuous improvement at the operation level. 5S is a process designed to organize the workplace, keep it clean, and maintain effective and standard conditions. It instils the discipline required to enable everyone to achieve and maintain a world-class environment.

The use of this tool was started in 1972 by Henry Ford in the United States as the CANDO programme: Cleaning up, Arranging, Neatness, Discipline and Ongoing improvement. The technique was popularized as 'Japanese 5S' in 1980 by Hiroyuki Hirano.

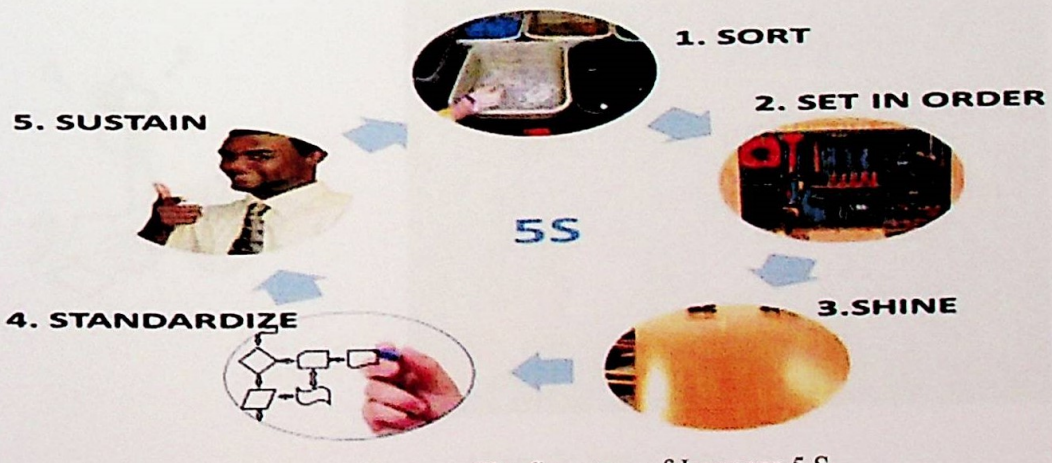


Figure 1. The five steps of Japanese 5 S

Why do we practice the 5S?

The general concept of the 5S is that they are intended to eliminate waste (Osada, 1993).

Working in disorder is neither productive, nor safe. 5S is a simple and practical method to instil a quality culture at the workplace. It is relatively easy to undertake and requires minimal additional resources.

Among the main benefits of implementing 5S are:

- The workplace becomes cleaner, safer, well-organized and more pleasant
- Floor space utilization is improved
- Workflow becomes smoother and more systematic and non-value-added activities are reduced;
- Time for searching tools, materials and document is minimized;
- Machine breakdowns are reduced since clean and well-maintained equipment breaks down less frequently and it also becomes easier to diagnose and repair before breakdowns occur, therefore extending equipment life;
- Errors are minimized leading to making defect-free products;
- Consumables and material wastage are minimized;
- The morale and satisfaction of employees improves; and
- The productivity of the organization improves together with the quality of products and services

1. SORT – SEIRI

The emphasis of Seiro is on stratification management and being able to spot the unwanted and unnecessary before they become problematic (Osada, 1993).





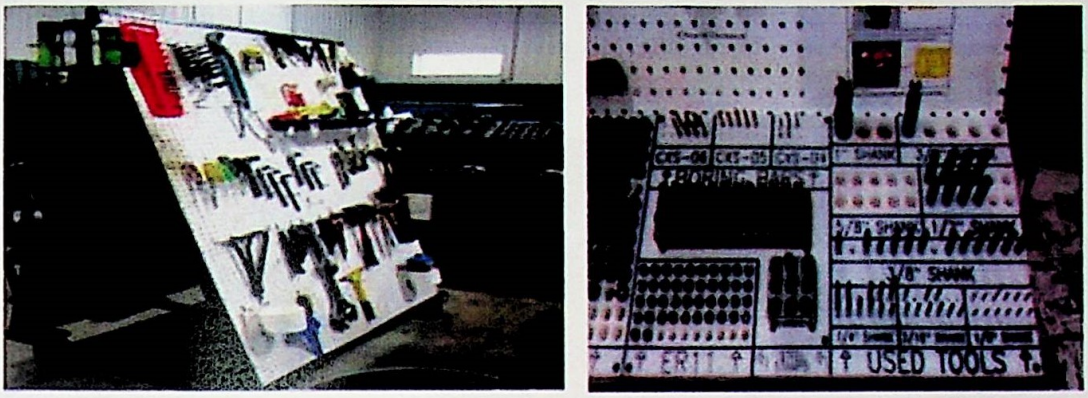
Figure 2: Sort – Seiro

Table 1: Sort - Seiri

MEANING	METHODS	BENEFITS
This means distinguishing or sort out between 'wanted' and 'unwanted items' at place of work and removal of unwanted items	First decide what is necessary and what is unnecessary. To find out unnecessary items you should not only check the floor but also shelves, lockers, storehouse, stairs, roofs, notice boards, etc. Your useful floor is saved. Your searching time of tools, materials, and papers is reduced. You have better flow of work. Your inventory cost of unnecessary items is reduced. • Put a red tag on unnecessary items and keep them in a separate area. • Discard or throw those items which have not been used in the past one year. • Things used once in 6 to 12 months may be stored at a distance from workstation. • Things used more than once a month should be available at a central point in the workplace. • Things used hourly/everyday/once a week should be near the workstation or may be worn by or kept in the pocket of your worker there.	Your useful floor is saved. Your searching time of tools, materials, and papers is reduced. You have better flow of work. Your inventory cost of unnecessary items is reduced.

2. SET IN ORDER - SEITON

Seiton can be defined as neatness, having things in the right places or set up so that they are readily available for use, eliminating the need to search. Once everything has a right place so that it's functionally placed for quality and safety, it can then be deemed that the workplace is neat (Osada, 1993). While Seiro helps you to decide what items are needed, Seiton helps you to decide the way things are to be placed.



Source: 5S Best Practices(www.5sbestpractices.ning.com)

Figure 3: Set-in-order – Seiton

Table 2: Set-in-order – Seiton

MEANING	METHODS	BENEFITS
• Arranging items in such a manner that they are easy to use. • Labelling them so that they are easy to find and put back. • This means a place for everything (necessary) and everything in its place. No more homeless items	If necessary, reassign spaces, racks, cabinets, etc. • Decide the right places for everything. • Put all materials and equipment at a place allocated to them with proper label or signalization. Use alerts or indications for out of stock situations. • Use floor paint marking to define working area, path, entrance/exit, safety equipment, cart/ trolley locations, etc. • Use standard colour coding for pipelines for steam, water, gas, drainage, etc. • Use display cautions, messages, instructions at proper place at proper height and written clearly	You take things out and keep things back easily. You make lesser mistakes. You reduce searching time. Your work environment becomes safe

3. SHINE - SEISO

Seiso places emphasis on cleaning so that things are clean; in other words, carrying out cleaning as a form of inspection i.e. getting rid of waste, and foreign matter. It is important to note that depending

on the circumstance, with higher quality, higher precision and finer processing technologies, even the minute details may have the greatest ramifications, hence the importance to carry out cleaning as a form of inspection (Osada, 1993).

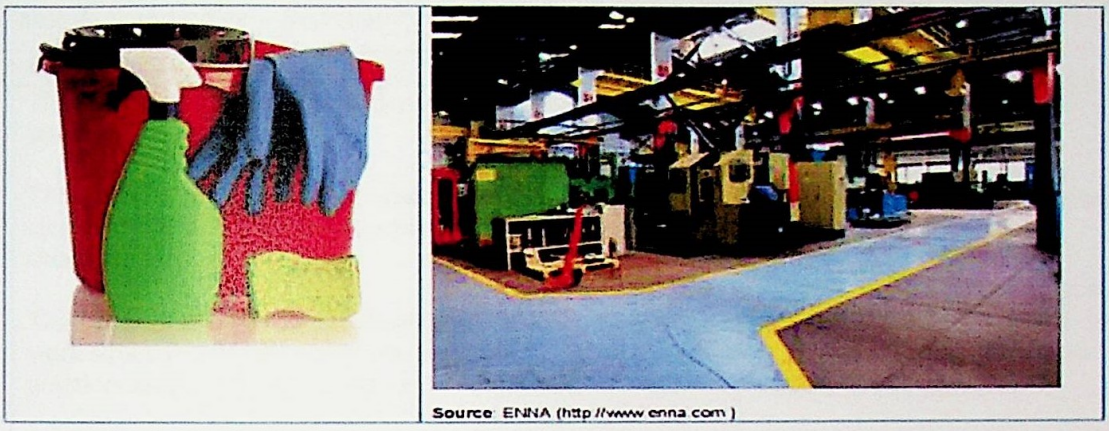


Figure 4: Shine – Seiso

Table 3: Shine – Seiso

MEANING	METHOD	BENEFITS
• This means removing dirt, strain, filth, soot and dust from the work area. • This includes cleaning and care for equipment and facilities and also inspecting them for abnormalities. In a way it also includes primary maintenance of equipment. • Note: Cleaning is not polishing, etc., to make the piece of equipment more beautiful – it looks after its condition and fitness for use.	• Divide the total area in zones and allocate responsibility for cleaning for each zone. • Decide on cleaning points, order of cleaning, type of cleaning aid required, etc. • Display cleaning schedule. • During cleaning look for defective conditions (loose bolts, vibrations, excessive sound, high temperature, fallen tools, etc.) and solve the problem. • Allocate space for storage of cleaning aids and consumables for cleaning.	Your workplace becomes free of dirt and stains which is the starting point for quality. Your equipment lifespan will be prolonged, and breakdowns will be less. Creates a pleasant environment. Prevents accidents.

4. STANDARDIZE - SEIKETSU

This aspect of the 5S focuses on standardization, making the first three S's, Seiro, Seiton, and Seiso a constant routine. The emphasis here is on visual management, an important aspect to attain and maintain standardized conditions to enable the individuals always act quickly (Osada, 1993).

Table 4: Standardize – Seiketsu

MEANING	METHODS	BENEFITS
This call for systematizing the above 4S practices. This means ensuring that whatever cleanliness and orderliness is achieved should be maintained. This requires that you should develop a work structure that will support the new practices and turn them into habits. The purpose of standardization is to make sure that everyone in the company follows the same procedure, the same names of items, the same size of signalization/floor marking, shapes, colours, etc. Standardize also helps to do the right thing the right way every time.	Document procedures and guidelines for sorting, set in order and shine. • Make a checklist for each section and train your people in using them • Carry out periodic evaluation by using the above check list. • Use visual management to act quickly, for example putting/using: – Open and shut directional labels on switches, etc. – Temperature and safety labels – Zone labels on measuring metres (normal zone, danger zone, etc.) – OK or hold marks on product. – Put transparency control – Make transparent covers of drawers. – Put inspection windows in the metal covers. – Use location maps with emergency exits, fire fighting equipment, etc.	Your activities will be simplified. You will have consistency in the work practices. You will avoid mistakes. With better visual and transparency management work efficiency will improve.

5. SUSTAIN – SHITSUKE

Shitsuke places emphasis on being able to forge a workplace with good habits and discipline. Demonstrating to others what needs to be done and encouraging practice amongst them. This is mainly a management responsibility.

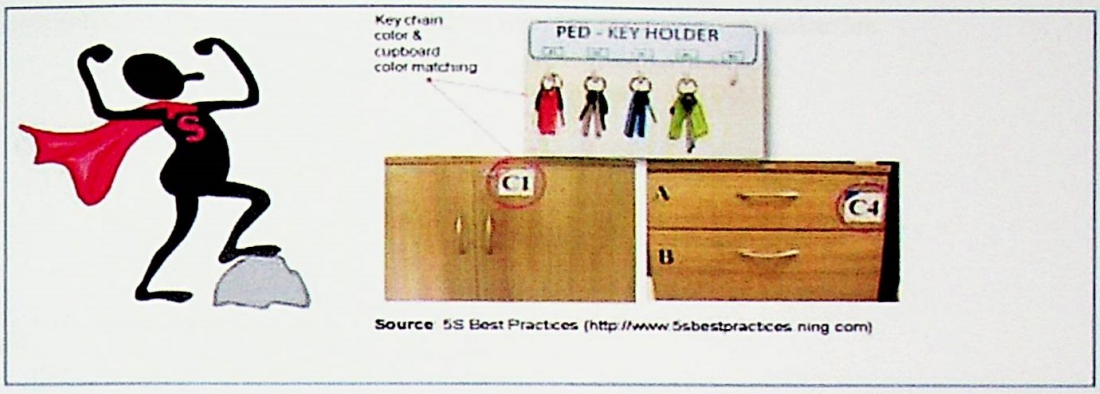
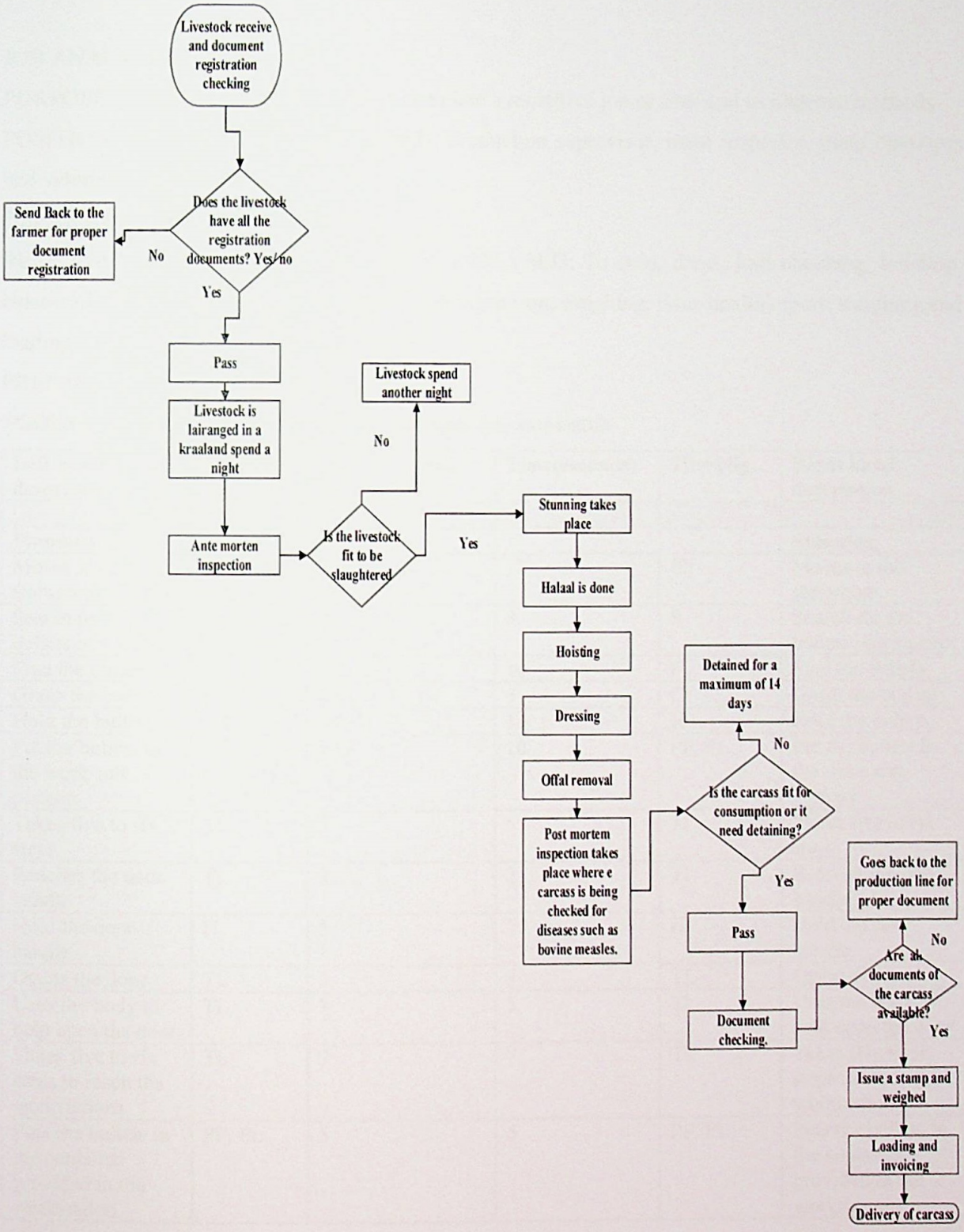


Figure 5: Sustain

Table 5: Sustain

MEANING	METHODS	BENEFITS
Sustain also means 'Discipline'. It denotes your commitment to maintain orderliness and to practice first 3S as a way of life. This also requires that your employees show positive interest and overcome resistance to change.	Create awareness and publicize the system. For example, develop 5S News, 5S Posters, 5S Slogans, 5S Day, etc. • Create a structure of how and when 5S activities will be implemented. • Formulate guidelines for audit/evaluation of 5S implementation. • Provide management support by providing resources and leadership. • Reward and recognize best performers.	Promotes habit for complying with workplace rules and procedures. Creates healthy atmosphere and a good workplace. Helps you to develop teamwork. Provides you with data for improving 5S.

Appendix G: Future proposed business process map after consultation



Appendix H: Motion study results of production section

JOB ANALYSIS: Motion study

PURPOSE: To determine the best way to complete a repetitive job or task and to improve methods

POSITION OF EMPLOYEES ANALYSED: Production supervisor, meat inspector, plant operators and veterinary officer

DEPARTMENT: Production section

RESPONBILITIES OF THE EMPLOYEES ANALYSED: To stun, dress, hall checking, hoisting, evisceration, offal separation, split, postmortem inspection, weighing, issue health report, weighing and loading carcass

PREPARED BY: Babedi

TOOLS USED: camera video recorder, computer and stopwatch

Left hand description	**Therblig**	**Time (seconds)**	**Time(seconds)**	**Therblig**	**Right hand description**
Stunning					**Stunning**
Moves to the storeroom	PP	12	12	PP	Moves to the storeroom
Search for the bullets of a stunner	S	8	8	S	Search for the bullets of a stunner
Find the bullets	F	10	10	F	Find the bullets
Grasp the bullets	G	3	3	G	Grasp the bullets
Hold the bullets	H	10	10	H	Hold the bullets
Put the bullets in the work suit pockets	PP, PL	10	10	PP, PL	Put the bullets in the work suit pockets
Takes five to six steps	TL	5	5	TL	Takes five to six steps
Reaches the door handle	TL	2	2	TL	Reaches the door handle
Hold the door handle	H	5	5	H	Hold the door handle
Opens the door	TL	3	3	TL	Opens the door
Uses the body to help open the door	TL	3	3	TL	Uses the body to help open the door
Takes five to six steps to reach the workstations	TL	7	7	TL	Takes five to six steps to reach the workstations
Puts the bullets in the container provided in the workstation	PP, PL	5	5	PP, PL	Puts the bullets in the container provided in the workstation

Places the container in a designated area	RL	2	2	RL	Places the container in a designated area
Stands in the workstation	AD	40	40	AD	Stands in the workstation
Stretches the body	R	15	15	R	Stretches the body
Bends and grasps the stunning bullets	G, R	25	25	G, R	Bends and grasps the stunning bullets
Select the stunning bullet	SE	5	5	SE	Select the stunning bullet
Holds the stunning bullets	H	15	15	H	Holds the stunning bullets
Bends and grasps the stunning machine	PP, G	12	12	PP, G	Bends and grasps the stunning machine
			20	H	Holds the stunning machine
Position the stunning bullet	P	5			
			5	P	Position the stunning machine
Load the bullets into the stunner	PP, TL	45	45	PP, TL	Load the bullets into the stunner
Puts the stunner nearby	PP	4	4	PP	Puts the stunner nearby
Waits for the cattle to be loaded	UD	3	3	UD	Waits for the cattle to be loaded
The operator is idle	AD	80	80	AD	The operator is idle
Grasps the loaded stunner	G	2	2	G	Grasps the loaded stunner
Hold it firmly	H	5	5	H	Hold it firmly
Position the loaded stunner	P	3	3	P	Position the loaded stunner
Picks the stunner	TL	6	6	TL	Picks the stunner
Operator uses a stunner	U	27	27	U	Operator uses a stunner
Operator puts the stunner down	RL	2	2	RL	Operator puts the stunner down
Unload the stunner	RL	4	4	RL	Unload the stunner
Holds it	H	4	4	H	Holds it
Removes the stunner cover cap	PP, RL	3	3	PP, RL	Removes the stunner cover cap
Removes the used bullet	PP, RL	5	5	PP, RL	Removes the used bullet
Stretches to relax the body	R	23	23	R	Stretches to relax the body
Select another stunning bullet to	SE	35	35	SE	Select another stunning bullet to

prepare for another cattle stunning					prepare for another cattle stunning
Load the stunner	TL	45	45	TL	Load the stunner
Holds the stunning machine	H	9	9	H	Holds the stunning machine
Closes the stunning cover cap	PP, TL	10	10	PP, TL	Closes the stunning cover cap
Halaal being done					**Halaal being done**
Operator select a knife to use	SE	4	4	SE	Operator select a knife to use
Bends the body	PP	7	7	PP	Bends the body
Grasps the knife	G	3	3	G	Grasps the knife
Position himself	P	8	8	P	Position himself
Operator waits for the beast to be stunned	AD	25	25	AD	Operator waits for the beast to be stunned
Operator is idle	AD	10	10	AD	Operator is idle
Stretches the body to relax	PP	13	13	PP	Stretches the body to relax
Holds the end corner of the stunning box to support his body	H	20	20	H	Holds the end corner of the stunning box to support his body
Opens the stunning cover board using a leg	TL	14	14	TL	Opens the stunning cover board using a leg
Closes the stunning cover board	RL	14	14	RL	Closes the stunning cover board
Picks the knife	PP, H	6	6	PP, H	Picks the knife
Holds it	H	3	3	H	Holds it
Position it	P	4	4	P	Position it
Uses it	U	240	240	U	Uses it
Puts it down	RL	10	10	RL	Puts it down
Takes two to three steps to place the knife in the sterilizer	PP	14	14	PP	Takes two to three steps to place the knife in the sterilizer
Hoisting					**Hoisting**
Takes four to three steps to pick the hoist controller	PP	12	12	PP	Takes four to three steps to pick the hoist controller
Press the mechanized hoist	TL, U	3	3	TL, U	Press the mechanized hoist
Adjust the mechanized hoist machine system	TL, U	2	2	TL, U	Adjust the mechanized hoist machine system

Controls the mechanized hoist machine system to move downward	U	5	5	U	Controls the mechanized hoist machine system to move downward
Position it	U, P	6	6	U, P	Position it
Direct it to grab the slaughter cattle's left leg	U, P	300	300	U, P	Direct it to grab the slaughter cattle's left leg
Grasps the beast's leg	G	360	360	G	Grasps the beast's leg
Controls the hoist machine system to move upward	U	240	240	U	Controls the hoist machine system to move upward
Leaves the hoists control system hanging	RL	120	120	RL	Leaves the hoists control system hanging
Stretches the body to relax	PP, R	60	60	PP, R	Stretches the body to relax
The operator helps the other operator by taking the knife from the other operator to sterilizer it	UD	600	600	UD	The operator helps the other operator by taking the knife from the other operator to sterilizer it
The operator waits for another beast to be slaughtered	AD	360	360	AD	The operator waits for another beast to be slaughtered
The operator is idle and doing nothing	AD	440	440	AD	The operator is idle and doing nothing
Bleeding and insertion of splitting hooks					**Bleeding and insertion of splitting hooks**
The operator takes seven to eight steps to board in the platform	PP	13	13	PP	The operator takes seven to eight steps to board in the platform
Press the controls of the platform to move upward	U, TL	33	33	U, TL	Press the controls of the platform to move upward
			3	U, TL	Uses the left leg for pressing the platform to form downwards
Search for the splitting hooks	S	86	86	S	Search for the splitting hooks
Find the splitting hooks	F	45	45	F	Find the splitting hooks

Select the required right splitting hooks.	SL	40	40	SL	Select the required right splitting hooks.
Moves seven to eight steps to reach the platform	PP	13	13	PP	Moves seven to eight steps to reach the platform
Position himself to board the platform	P	25	25	P	Position himself to board the platform
			31	PP, TL	Uses the right leg to press controls of the platform to switch it on
Presses the platform controls	U	4	4	U	Presses the platform controls
Stand firmly	PP	21	21	PP	Stand firmly
Presses the platform to switch it off	U	40	40	U	Presses the platform to switch it off
Waits for the beast to bleed	UD	123	123	UD	Waits for the beast to bleed
Operator is idle	AD	23	23	AD	Operator is idle
Picks the knife	TL	9	9	TL	Picks the knife
Bends to pick it	PP, TL	36	36	PP, TL	Bends to pick it
Select the required one	SL	34	34	SL	Select the required one
Uses it to cuts the hoofs	U	135	135	U	Uses it to cuts the hoofs
Operator waits for another slaughtered cattle	UD	600	600	UD	Operator waits for another slaughtered cattle
Operator is idle	AD	900	900	AD	Operator is idle
Skinning of the head					**Skinning of the head**
The operator moves two to three steps to reach the platform	PP	12	12	PP	The operator moves two to three steps to reach the platform
Stand on the platform	R	50	50	R	Stand on the platform
Presses the platform to switch it on to reach the carcass to skin the head	U	24	24	U	Presses the platform to switch it on to reach the carcass to skin the head
Stand on the platform to reach the required distance	TL, R	34	34	TL, R	Stand on the platform to reach the required distance

Presses the platform to switch it on	U	41	41	U	Presses the platform to switch it on
Stretches to relax the body	RL, PP	34	34	RL, PP	Stretches to relax the body
Bends the body	PP	12	12	PP	Bends the body
Select he knife for skinning the head	SL	23	23	SL	Select he knife for skinning the head
Holds the knife	H	14	14	H	Holds the knife
Uses the knife	U	1200	1200	U	Uses the knife
Moves the knife to the right hand	RL	25	25	RL	Moves the knife to the right hand
			14	TL	Receives the knife
			45	H	Holds the knife
			24	PP, RL	Stretches the hand to put the knife in a sterilizer
Puts the knife in a sterilizer	TL	29	29	TL	Puts the knife in a sterilizer
The operator waits for another slaughtered beast to work on	AD	356	356	AD	The operator waits for another slaughtered beast to work on
The operator stands in the platform and is idle	AD	322	322	AD	The operator stands in the platform and is idle
Skinning of head & carcass and removal of hoofs					**Skinning of head & carcass and removal of hoofs**
Operator takes two to four to reach the workstation where the skinned head and hoof are disposed	PP	24	24	PP	Operator takes two to four to reach the workstation where the skinned head and hoof are disposed
Operator bends the body	PP	30	30	PP	Operator bends the body
Operator arrange the hoofs	PL, PP	35			
Operator select one hoof	SL	45	45	SL	Operator select another hoof
Puts and position them in such a way there will be light to carry	RL, P	86	86	RL, P	Puts and position them in such a way there will be light to carry
Grasps the hoof	G	45	45	G	Grasps the hoof

Takes five steps to move to the hoofs loading side	TL	20	20	TL	Takes five steps to move to the hoofs loading side
Bends the body	PP	35	35	PP	Bends the body
Release the load	RL	40	40	RL	Release the load
Stretches to relax	PP	56	56	PP	Stretches to relax
Takes five steps to move to the designated area	PP	17	17	PP	Takes five steps to move to the designated area
Stretches the body	PP, R	58	58	PP, R	Stretches the body
Bends the body to grab the skinning head	PP, G	156	156	PP, G	Bends the body to grab the skinning head
Picks skinned head	H, TL	58	58	H, TL	Picks skinned head
Hold it	H	62	62	H	Hold it
Position skinned head	P	71	71	P	Position skinned head
Lifts it up	U	89	89	U	Lifts it up
Position it and hold it firmly	P, H	78	78	P, H	Position it and hold it firmly
Moves six steps where skinned head are kept and systematically	PP	59	59	PP	Moves six steps where skinned head are kept and systematically
Moves three steps to reach the trolley	PP	11	11	PP	Moves three steps to reach the trolley
Search hooks which are used to handle the heads	S	23	23	S	Search hooks which are used to handle the heads
Find them	F	61	61	F	Find them
Moves three steps	PP	6	6	PP	Moves three steps
Uses both hands and a body to push the trolley to the designated area	U			U	Uses both hands and a body to push the trolley to the designated area
Bends and put them, releasing them	PP, RL	27	27	PP, RL	Bends and put them, releasing them
Takes four steps to search for tags that are used for tagging skinned heads	PP, S	75	75	PP, S	Takes four steps to search for tags that are used for tagging skinned heads
Find the tags	F	41	41	F	Find the tags
Holds them firmly	H	37	37	H	Holds them firmly
Moves back by taking five steps	PP	9	9	PP	Moves back by taking five steps
Arrange the heads systematically	PL	19	19	PL	Arrange the heads systematically
Tag them	U	46	46	U	Tag them

Operator is idle	AD	57	57	AD	Operator is idle
Operator waits for another skinned head so that it can be arranged	UD	32	32	UD	Operator waits for another skinned head so that it can be arranged
Dressing					**Dressing**
Operator picks the hider	TL	105	105	TL	Operator picks the hider
Takes five to six steps to move to the platform	PP	35	35	PP	Takes five to six steps to move to the platform
Stand on the platform	TL	45	45	TL	Stand on the platform
Uses the left leg to switch on the platform	U	23			
Stand on the platform	PP	12	12	PP	Stand on the platform
			13	U	Uses the right leg to switch on the platform
Holds the hider	H	63	63	H	Holds the hider
Position it	P	7	7	P	Position it
Uses the hider	U	19	19	U	Uses the hider
Operator picks the hider and puts it in its designated area	TL	45	45	TL	Operator picks and puts it in its designated area
Operator presses the platform to switch it on	U	23	23	U	Operator presses the platform to switch it on
Operator uses the platform to move downwards	U	25	25	U	Operator uses the platform to move downwards
Operator goes outside the platform	RL	39	39	RL	Operator goes outside the platform
Stretches the body to relax	PP, R	77	77	PP, R	Stretches the body to relax
Operator is idle by using his phone	AD	105	105	AD	Operator is idle by using his phone
Operator takes a rest	R	653	653	R	Operator takes a rest
Operator waits for another carcass to work on	UD	660	660	UD	Operator waits for another carcass to work on
Evisceration					**Evisceration**
The operator takes two to three steps	PP	17	17	PP	The operator takes two to three steps

to collect saw that is going to be used for eviscerating operation					to collect saw that is going to be used for eviscerating operation
Search for the sharp saw	S	360	360	S	Search for the sharp saw
Find the saw	F	300	300	F	Find the saw
Select the sharp saw	SL	401	401	SL	Select The sharp saw
			36	H	Hold the saw
Grasp the saw	G	20			
Operator takes four steps to move to the designated area	PP	33	33	PP	Operator takes four steps to move to the designated area
Take one step to board inside the platform	PP	12	12	PP	Take one step to board inside the platform
Uses the left leg to switch the platform control system on	U	39	39	U	Uses the left leg to switch the platform control system on
Stand on the platform as it moves upwards to the required distance	TL, P	85	85	TL, P	Stand on the platform as it moves upwards to the required distance
			90	U	Presses the platform to switch it off
Position the saw	P	75			
Uses the saw	U	670	670	H, U	Hold the end saw handle
Puts the saw inside the platform	RL	15	15	RL	Puts the saw inside the platform
Operator is idle and takes news with the operator	AD	39	39	AD	Operator is idle and takes news with the operator
Operator switches the platform on to move downwards	U	11	11	U	Operator switches the platform on to move downwards
Operator stretches to relax the body	PP, R	91	91	PP, R	Operator stretches to relax the body
Operator waits for another skinned carcass to work on	UD	660	660	UD	Operator waits for another skinned carcass to work on
Offal separation					**Offal separation**
Operator takes three to five steps	PP	20	20	PP	Operator takes three to five steps

to grab the mechanized hoist machine system					to grab the mechanized hoist machine system
Uses the mechanized hoist machine system	U	43	43	U	Uses the mechanized hoist machine system
Bends the body	P	31	31	P	Bends the body
Position the holding tray for green and red offal	P	45	45	P	Position the holding tray for green and red offal
Position the holding tray	P	34	34	P	Position the holding tray
Operator takes off both red and green offal from the carcass	TL	61	61	TL	Operator takes off both red and green offal from the carcass
Uses the mechanized hoist machine to move the carcass upwards	U	379	379	U	Uses the mechanized hoist machine to move the carcass upwards
Operator stretches to relax the body	PP, R	67	67	PP, R	Operator stretches to relax the body
Operator rests	R	1200	1200	R	Operator rests
Operator helps a colleague to push the trolley into the production line shop floor	U, UD	723	723	U, UD	Operator helps a colleague to push the trolley into the production line shop floor
Operator waits for another eviscerated carcass to work on	AD	421	421	AD	Operator waits for another eviscerated carcass to work on
Splitting hooks removal					**Splitting hooks removal**
Operator stand inside the platform	PP, U	25			
			334	U	Uses the right leg to switch the platform on
Position the platform machine system in such a way that it will be easy to reach the carcass	U, P	462			
			12	U	Presses the platform to switch it off

Removes the splitter hooks	U	427			
Picks the single hooks that are always hanged along the production line	P, G, H	179			
Insert the single hooks in the carcass right leg	U	390			
			390	U	Insert the single hooks in the carcass left leg
Operator waits for another carcass	AD	204	204	AD	Operator waits for another carcass
Stretches the body to relax	PP, R	154	154	PP, R	Stretches the body to relax
Carcass splitting					**Carcass splitting**
Operator stand inside the platform	PP	36	36	PP	Operator stand inside the platform
			49	U	Uses the right leg to switch the platform on
Position the platform machine system in such a way that it will be easy to reach the splitting machine	P	123	123	P	Position the platform machine system in such a way that it will be easy to reach the splitting machine
Uses the left leg to switch the platform off	U	8	8	U	Uses the left leg to switch the platform off
Reach the splitting machine	F	45	45	F	Reach the splitting machine
Uses the splitting machine	U	59	59	U	Uses the splitting machine
Operator puts the splitting machine in a sterilizer	RL, PP	73	73	RL, PP	Operator puts the splitting machine in a sterilizer
Operator waits for another carcass to work on	AD	273	273	AD	Operator waits for another carcass to work on
Tagging and sticking					**Tagging and sticking**
Operator takes three steps to move to the place	PP	31	31	PP	Operator takes three steps to move to the place where tags are placed

where tags are placed					
Select the specific tags	SL	97	97	R	Steady
			101	H	Hold tags
Checks the killing agenda book	I	150	150	I	Checks the killing agenda book
Confirms correspondence of killing agenda book together with the prepared tags for that day	I	152	152	I	Confirms correspondence of killing agenda book together with the prepared tags for that day
Operator puts a tag on the carcass	U	13	13	U	Operator puts a tag on the carcass
Operator puts tags on the skinned head, green and red offal's	U	70	70	U	Operator puts tags on the skinned head, green and red offal's
Carcass, red & green offal inspection					**Carcass, red & green offal inspection**
Meat inspector select the sharp sterilized knife from the sterilizer container	SL	37	37	SL	Meat inspector select the sharp sterilized knife from the sterilizer container
Holds the knife	H	13	13	H	Steady
Position the knife	P	22	22	P	Position the knife
Uses the body to position the carcass	U	127	127	U	Uses the body to position the carcass
Uses the knife to make cuts in the carcass	U	179	179	U	Uses the knife to make cuts in the carcass
Inspect the carcass	I	231	231	I	Inspect the carcass
Holds the knife	H	24	24	H	Holds the knife
Bends the body to put the knife in a sterilizer	PP, U	77	77	PP, U	Bends the body to put the knife in a sterilizer
Takes three to four steps to move to where skinned heads are hanged	PP	31	31	PP	Takes three to four steps to move to where skinned heads are hanged
Search for a sharp knife	S	360	360	S	Search for a sharp knife
			93	F	Find the sharp knife

Select a sharp knife	SL	8			
Position the skinned head	P	46	46	P	Position the skinned head
Uses the sharp knife to make cuts on the skinned head	U	98	98	U	Uses the sharp knife to make cuts on the skinned head
Inspect the skinned head	I	127	127	I	Inspect the skinned head
Inspect the red offal	I	134	134	I	Inspect the red offal
Inspect the green offal	I	140	140	I	Inspect the green offal
Move three to four steps to attend to the waiting carcass	PP	13	13	PP	Move three to four steps to attend to the waiting carcass
Carcass, red & green offal washing					**Carcass, red & green offal washing**
Operator moves five to six steps to reach the hosepipe tap	PP	10	10	PP	Operator moves five to six steps to reach the hosepipe tap
Bends the body to switch the tap on	PP	17	17	PP	Bends the body to switch the tap on
Holds the hose pipe	H	56	56	H	Holds the hose pipe
Position the horse pipe	P	59	59	P	Position the horse pipe
Wash the skinned head	U	390	390	U	Wash the skinned head
Wash the red offal	U	400	400	U	Wash the red offal
Wash the work floor	U	395	395	U	Wash the work floor
Wash the green offal	U	401	401	U	Wash the green offal
Operator moves five to six steps to reach the hosepipe tap	PP	11	11	PP	Operator moves five to six steps to reach the hosepipe tap
Bends the body to switch the tap off	PP	27	27	PP	Bends the body to switch the tap off
Operator takes five to six steps to move back to the designated area	PP	14	14	PP	Operator takes five to six steps to move back to the designated area
Operator stretches the body to relax	PP	12	12	PP	Operator stretches the body to relax

Operator is idle to waits for another carcass, green offal, skinned head and red offal to wash	AD	15	15	AD	Operator is idle to waits for another carcass, green offal, skinned head and red offal to wash
Carcass, Red & green offal inspection					**Carcass, Red & green offal inspection**
Veterinary officer takes five to six steps from her office into the production shop floor	PP	13	13	PP	Veterinary officer takes five to six steps from her office into the production shop floor
Inspects all the operations	I	840	840	I	Inspects all the operations
Inspect the loading truck	I	450	450	I	Inspect the loading truck
Records any abnormalities within the plant	I, U	980	980	I, U	Records any abnormalities within the plant
Checks correspondence of all documents and information recorded by the production manager, supervisor, ante-mortem officer, security Guards, meat inspector and operators.	I	1200	1200	I	Checks correspondence of all documents and information recorded by the production manager, supervisor, ante-mortem supervisor officer, security Guards, meat inspector and operators.
Search for a pen	S	16	16	S	Search for a pen
Find a pen	F	21			
			21	SL	Choose a blue pen to write with
Takes four steps to move back to her office	PP	32	32	PP	Takes four steps to move back to her office
			453	U	Uses the pen
Puts the pen down	RL	421			
Pick a stamp	TL	36			
			75	U	Uses the stamp
Stretches to relax the body	PP, R	45	45	PP, R	Stretches to relax the body
Rest the body	R	180	180	R	Rest the body

Veterinary officer is idle and waits for another carcass to work on	AD	371	371	AD	Veterinary officer is idle and waits for another carcass to work on
Pre-loading					**Pre-loading**
Operator uses the body to push the carcass	PP, U	769	769	PP, U	Operator uses the body to push the carcass
Stretches to relax the body	PP, R	231	231	PP, R	Stretches to relax the body
Rest the body	R	423	423	R	Rest the body
Operator is idle and waits for another carcass to work on	AD	235	235	AD	Operator is idle and waits for another carcass to work on
Weighing					**Weighing**
Operator picks the killing agenda	U	75	75	U	Operator picks the killing agenda
Takes five to six steps to where the carcass is weighed	PP	125	125	PP	Takes five to six steps to where the carcass is weighed
Reaches the weighing section	G	15	15	G	Reaches the weighing section
Stand near the carcass weighing scale	R	68	68	R	Stand near the carcass weighing scale
Bends the body	PP	23	23	PP	Bends the body
Uses the left hand to reset the weighing scale	U	47	47	U	Uses the left hand to reset the weighing scale
Awaits the carcass to be pass through the scale	UD	47	47	UD	Awaits the carcass to be pass through the scale
Observe the carcass as it passes through the scale	I	79	79	I	Observe the carcass as it passes through the scale
Puts the hand in the pocket to take the pen	PP, S, TL	32	32	PP, S, TL	Puts the hand in the pocket to take the pen
Uses the pen	U	78	78	U	Uses the pen
Operator is idle waiting to weigh another carcass	AD	345	345	AD	Operator is idle waiting to weigh another carcass
Loading					**Loading**
Operator stretches the body	PP, R	24	24	PP, R	Operator stretches the body

Operator bends the body to pick the carcass	PP	31	31	PP	Operator bends the body to pick the carcass
Stretches the hands to handle the carcass	PP	29	29	PP	Stretches the hands to handle the carcass
Moves three steps to position the body	PP	30	30	PP	Moves three steps to position the body
Grab the carcass with both hands	G	35	35	G	Grab the carcass with both hands
Holds the carcass firmly	H	37	37	G	Holds the carcass firmly
Inspect the loading truck	I	301	301	I	Inspect the loading truck
Load the carcass	TL	23	23	TL	Load the carcass
Load the red offal	TL	69	69	TL	Load the red offal
Load the skinned head	TL	79	79	TL	Load the skinned head
Load the green offal	TL	89	89	TL	Load the green offal
Invoicing					**Invoicing**
Moves three to four steps to the weighing area	PP	13	13	PP	Moves three to four steps to the weighing area
Talks with the weighing	AD	39	39	AD	Talks with the weighing
Chat with the weighing operator	AD	41	41	AD	Chat with the weighing operator
Request for the carcass weight information	UD	32	32	UD	Request for the carcass weight information
Moves three to four steps to his designated area	PP	24	24	PP	Moves three to four steps to his designated area
Inspects and checks the information in the recording book	I	354	354	I	Inspects and checks the information in the recording book
Finds a pen	F	17	17	F	Finds a pen
Select a blue pen	SL	21	21	H	Holds the pen firmly
Uses the pen	U	31	31	R	Steady
Issue an invoice	U	45	45	U	Issue an invoice
The operator stretches the body to relax	PP, R	65	65	PP, R	The operator stretches the body to relax

Green offal cleaning					**Green offal cleaning**
Receives the green offal	G, H	57			
Bends the body and counts the received green offal	PP, I, U	65	65	PP, I, U	Bends the body and counts the received green offal
Sort them	U	64	64	U	Sort them
Bends the body	PP	13	13	PP	Bends the body
Search for a sharp knife to use	S	47	47	S	Search for a sharp knife to use
Find the knives to use	F	79	79	F	Find the knives to use
Operator selects the knife	SL	11	11	SL	Operator selects the knife
Operator stretches the body to relax	PP, R	57	57	PP, R	Operator stretches the body to relax
Uses the knife to remove waste from the green offal	U	77	77	U	Uses the knife to remove waste from the green offal
Bends the body	PP	31	31	PP	Bends the body
Clean the green offal in a container full of water	U	46	46	U	Clean the green offal in a container full of water
Operator stretches the body to relax	PP	24	24	PP	Operator stretches the body to relax
Truck loading					
Driver takes three to four steps to reach the truck where it was parking	PP	13	13	PP	Driver takes three to four steps to reach the truck where it was parking
Board the truck	TL	43	43	TL	Board the truck
Position the body	P	37	37	P	Position the body
Search for the keys	S	53	53	S	Search for the keys
Find the truck keys	F	65	65	H	Hold the truck keys
			79	U	Uses the truck key to start the loading truck
Drives the loading truck to the carcass loading area	U, TL	171	171	U	Drives the loading truck to the carcass loading area

Park the loading truck in the carcass loading area	U, RL	97	97	U, RL	Park the loading truck in the carcass loading area
Switch off the truck	U	77	77	U	Switch off the truck
Operator position himself	P	46	46	P	Operator position himself
Board the loading truck	74	74	74	U, RL	Board the loading truck
Help the operators to load the carcass	UD	98	98	UD	Help the operators to load the carcass
Truck driver stretches the body to relax	PP	103	103	PP	Truck driver stretches the body to relax
Truck driver is idle waiting for another carcass to be loaded	UD	53	53	UD	Truck driver is idle waiting for another carcass to be loaded

Appendix I: Time study sheet

TIME STUDY DATA SHEET

DATE:..... NAME OF OPERATION:.....

NAME OF OPERATOR:..... MACHINE TYPE:.....

NAME OF OPERATION	OBSERVED TIME					NO OF CYCLES	R	W	OT	NT
	1	2	3	4	5					

SUMMARY							Allowance Summary (ILO recommended allowances)				
Total OT							personal needs	5			
Rating							Basic fatique	4			
Total NT							Variable fatique	0			
No. observations							Special	0			
Average NT							Total	9			
% allowance											
Standard time											

STUDY CONDUCTED BY :.....

DATE: .....

SIGNATURE:.....

Appendix J: Observed Time study results for five cycles

Section	Operations	Observed Time (in seconds)					Average Observed time (seconds)
		Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	
Receiving	Inspecting the loaded truck	50	55	55	64	76	60
	Collecting documents from the recepient	70	81	85	75	79	78
	Recording information in the killing agenda book	130	114	119	124	128	123
	TOTAL	250	250	259	263	283	261

Section	Operations	Observed Time (in seconds)					Average observed time (seconds)
		Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	
Lairaging	Offloading	1045	1043	1044	1045	1043	1044
	Branding cattle for identification	261	262	263	259	260	261
	Lairaging	575	570	578	575	572	574
	Cattle spending a night	75131	75131	75131	75131	75131	75131
	Ante-mortem inspection	625	628	623	624	630	626
	Verification of papers	676	673	680	679	682	678
	Sorting	156	152	159	155	158	156
	TOTAL	2293	2285	2303	2292	2302	2296

Section	Operations	Observed Time (in seconds)					Average Observed time (seconds)
		Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	
Production shop floor	Stunning	50	51	54	52	53	52
	Halaal being done	100	102	107	107	104	104
	Hoisting	53	52	54	51	50	52
	Bleeding	106	107	107	103	102	105
	Skinning of heads	260	259	263	262	261	261
	Dressing	211	210	209	207	208	209
	Evisceration	160	156	159	153	157	157
	Offal separation	208	207	209	210	211	209
	Splitting of carcass	262	261	263	259	260	261
	Carcass tagging	53	52	54	51	50	52
	Head tagging	102	103	107	107	106	105
	Head sorting	153	157	159	156	160	157
	Red offal washing	103	106	107	107	102	105
	Green offal washing	160	156	159	157	153	157
	Red offal inspection	107	107	103	102	106	105
	Green offal inspection	153	157	160	156	159	157
	Carcass inspection	106	102	103	107	107	105
	Post-mortem inspection	211	210	209	207	208	209
	Report preparing	102	107	106	107	103	105
	Report issuing	208	207	211	209	210	209
	Detaining	300522	300522	300522	300522	300522	300522
	Truck inspection	260	259	263	261	262	261
	Weighing	210	209	208	211	207	209
	Loading of carcass	207	211	208	209	210	209
	Red offal loading	103	107	106	107	102	105
	Green offal loading	158	155	159	152	156	156
	Invoicing	211	210	209	208	207	209
	TOTAL	4017	4020	4056	4018	4014	4024

Appendix K: Standard time results

Section	Operations	Observed time (seconds)	PFD allowance	Performance rating	Calculated Time
Receiving	Inspecting the loaded truck	60	15%	100%	69
	Collecting documents from the recepient	78	15%	100%	89.7
	Recording information in the killing agenda book	123	15%	100%	141.45
	TOTAL	261			300

Section	Operations	Observed time (seconds)	PFD allowance	Performance rating	Calculated Time
Lairaging	Offloading	1044	15%	100%	1200.6
	Branding cattle for identification	261	15%	100%	300.15
	Lairaging	574	15%	100%	660.1
	Cattle spending a night	75131	15%	100%	86400.65
	Ante-mortem inspection	626	15%	100%	719.9
	Verification of papers	678	15%	100%	779.7
	Sorting	157	15%	100%	180.55
	TOTAL	2296			2640

Section	Operations	Observed time (seconds)	PFD allowance	Performance rating	Calculated Time
Production	Stunning	52	15%	100%	59.8
	Halaal being done	104	15%	100%	119.6
	Hoisting	52	15%	100%	59.8
	Bleeding	105	15%	100%	120.75
	Skinning of heads	261	15%	100%	300.15
	Dressing	209	15%	100%	240.35
	Evisceration	157	15%	100%	180.55
	Offal separation	209	15%	100%	240.35
	Splitting of carcass	261	15%	100%	300.15
	Carcass tagging	52	15%	100%	59.8
	Head tagging	105	15%	100%	120.75
	Head sorting	157	15%	100%	180.55
	Red offal washing	105	15%	100%	120.75
	Green offal washing	157	15%	100%	180.55
	Red offal inspection	105	15%	100%	120.75
	Green offal inspection	157	15%	100%	180.55
	Carcass inspection	105	15%	100%	120.75
	Post-mortem inspection	209	15%	100%	240.35
	Report preparing	105	15%	100%	120.75
	Report issuing	209	15%	100%	240.35
	Detaining	300522	15%	100%	345600.3
	Truck inspection	261	15%	100%	300.15
	Weighing	209	15%	100%	240.35
	Loading of carcass	209	15%	100%	240.35
	Red offal loading	105	15%	100%	120.75
	Green offal loading	156	15%	100%	179.4
	Invoicing	209	15%	100%	240.35
	TOTAL	4024			4620

Appendix L: List of equipment and tools used in the slaughtering of cattle

EQUIPMENT AND TOOLS USED FOR SLAUGHTERING A CATTLE IN BOTSWANA PRIVATE ABATTOIR		
Receiving Section	**Lairaging section**	**Production shop floor**
-pen	-unloading ramp	-stunner
-pencil	-racing cage	-platform
-ruler	-sticks	-paunch clip applicator
-killing agenda book	-choker	-shackle wall hooks
	-reader	-carcass rail
	-RFID	-hoist
		-trim station platform
		-catch tray
		-splitting saw
		-knife sterilizer
		-knife sharpener
		-trolley
		-plastic bag dispenser
		-hider
		-carcass splitting
		-hose reel
		-hose
		-wash nozzle
		-monorail beam
		-slide spreader
		-evisceration platform
		-legging platform
		-insect zappers
		-knapsack sanitizer sprayer
		-storage rack
		-drain pack

Appendix M: Detailed process of slaughtering of a beast

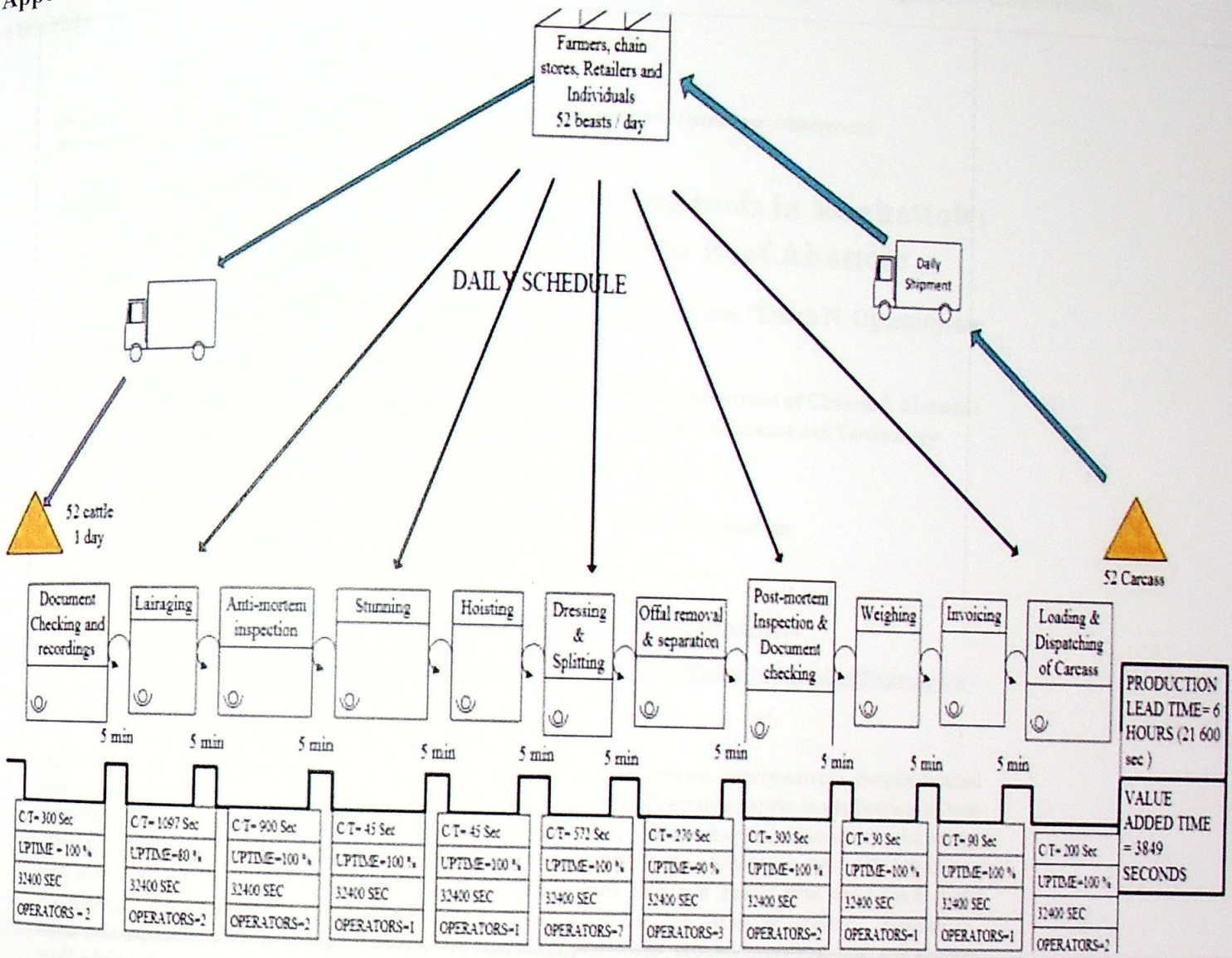
SECTION	OPERATION	PURPOSE
RECEIVING CATTLE AT THE GATE	Opening of the gate to allow the delivery man to enter the building	
	Offering greetings to the delivery man	
	Inspecting the truck and cattle registrations	
	Checking the correspondence of the cattle documents submitted by the delivery man	
	Recording the information in the killing agenda book	
	Cattle are allowed to enter the building after all recordings have been captured	
LAIRAGING	Offloading takes place	
	Branding cattle for identification	
	Lairaging	
	Cattle spending a night	
	Ante-mortem inspection	
	Verification of papers	
	Sorting of cattle	
PRODUCTION SHOP FLOOR	Stunning	
	Halaal being done	
	Hoisting	
	Bleeding	
	Skinning of heads	
	Dressing	
	Evisceration	
	Offal separation	
	Splitting of carcass	
	Carcass tagging	
	Head tagging	
	Head sorting	
	Red offal washing	
	Green offal washing	
	Red offal inspection	
	Green offal inspection	
	Carcass inspections	
	Post-mortem inpections	
	Report preparing	
	Report issuing	
	Detaining	
	Truck inspection	
	Weighing	
	Loading of carcass	
	Red offal loading	
	Green offal loading	
	Invoicing	

Appendix N: Proposed Template of Business and Production Process Documentation

Name of Process:	Business and Production Process of Botswana Private Abattoir		
Process Owner:	_____		
Created By:	_B. Kufigwa___	**Last Updated By:**	_____
Date Created:	_/_/2018	**Last Revision Date:**	_/_/2018
Process Purpose:	The purpose of the Business and Production Process is to improve Botswana Private Abattoirs, ability to swiftly and efficiently identify and fill business and production requirements by implementing a standardized organizational process with participation from each employee.		
Process Scope:	This process pertains to document abattoirs processes so as to create standard operating procedures (SOP)		
Process Input:	The process input starts when farmers agree for the charges for their cattle to be slaughtered in the abattoir		
Process Boundaries:	The activities immediately following the process input and immediately preceding the process output where invoices are collected for individuals for balancing accounts		
Process Flow:	1. Cattles are received, their document is checked, and cattle registrations is approved 2. Offloading 3. Branding of cattle's takes place 4. Lair aging 5. Anti-mortem inspection 6. Sorting 7. Stunning 8. Hoisting 9. Carcass is hoisted in a rail to bleed 10. Head skinning 11. Dressing 12. Splitting 13. Offal removal and separation 14. Post- mortem inspection by meat inspector together with veterinary office inspector		

	15. Veterinary officer inspector checks correspondence of the carcasses documents and issue an establishment stamp 16. Weighing 17. Invoicing 18. Loading of carcass and dispatch carcass to the customer 19. Delivery of carcass to the customer
Process Output:	The output for this process is invoices used for balancing money received on that day for accounts reporting
Exceptions to Normal Process Flow:	1. In steps 1-6, if no cattle are allowed into the building then production does not take place on that day 2. In step 1 no cattle is allowed into the building without the owner's affidavit to provide proof that surely this is his/her cattle, a permit and a letter from kgotla. 3. In step 14, when the carcass has some disturbing conditions such as measles or diseases it is detained for a maximum of four days or it is burned if the veterinary office and the meet inspector provide a substantial report that the carcass is not good for human consumption.
Control Points and Measurements:	1. A control point and measurement are established in step 7 of the process flow. The process owner will continuously measure the cycle time it takes to release a carcass. If the cycle time is high it means, there is high lead time therefore there is need to optimize the existing process and eliminate unnecessary waste. 2. A control point and measurement are established in step 19 of the process flow. If the available cattle are less than hundred in a day but the process cannot allow them to be slaughtered in that day it means root cause steps will need to be taken to determine why the company cannot meet its target slaughter per day.

Appendix O: Future State Map



Appendix P: Publication with Industrial Engineering and Operations Management Conference (IEOM)

Proceedings of the International Conference on Industrial Engineering and Operations Management
Pretoria / Johannesburg, South Africa, October 29 – November 1, 2018

Implementation of Lean manufacturing tools in an abattoir: A case study of a Botswana Private Beef Abattoir

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Abstract

Application of lean manufacturing tools in abattoirs promise great process improvements, despite limited sources and literature specific to abattoirs. Due to the inadequacy of research papers in application of lean manufacturing tools in abattoir; audits, process efficiency measurements, document analyzing, identification of value adding and non-value adding activities, site visits, plant tours, conducting trainings and awareness, motion study, work and method study, plant tour and observation were used. Data collection, recommendations and improvements were made on the basis of authors' knowledge, observations, audits results, change management responses, feedbacks, process measurements, and abattoir staff advice. Lean manufacturing tools, practices and philosophies that succeeded in carrying out the research in abattoirs are takt, standardization, 5S and waste elimination, value stream mapping. These lean manufacturing tools improved business processes, work methods and productivity. This paper reports on the introduction of lean manufacturing tools in one of Botswana Private Beef Abattoir. The contribution highlights before and after lean implementation in terms cost saving improvements, work method improvements, workplace safety awareness, 21-23 % cycle time improvements, 20-22% process efficiency improvement and recommendation to waste management practices that the company can absorb.

Keywords: business process improvement, work study, lean manufacturing, beef abattoir, method study

Appendix Q: Publication with BIUST, RDAIS 2019

BIUST Research and Innovation Symposium 2019 (RDAIS 2019)
Botswana International University of Science and Technology
Palapye, Botswana, 4 - 7 June 2019

ISSN: 2521-2292

Paper Title: Productivity improvement using value stream mapping in a beef abattoir

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Abstract **Beef abattoirs continue to face challenges of improving productivity, in order to remain successful in a highly competitive industry. As every input cost goes higher year on year, it is important to provide better products, processes and services at lower costs to the end user by improving process cycle time efficiency of the plant. The aim of this paper is to illustrate the implementation of value stream in a beef abattoir to improve productivity. This study started with conducting site visits, touring the plant, conducting interviews, direct observation and conducting time study for the existing current production process. Current process was mapped to identify problems and bottlenecks within the beef abattoir. Long manufacturing lead time, waiting or delays within the production and too much time spent on handling the carcass. In order to address these productivity inefficiencies in a beef abattoir; future state map, estimated calculated process improvements and suggestions were proposed on how value adding time can be improved. These proposed improvements and calculated process cycle time efficiency could lead to a better system for the organization under study. The contribution highlights 21-23% process cycle time improvements and efficiency.**

Keywords: beef abattoir; cycle time efficiency; process improvement; value stream mapping

Introduction

Beef abattoir in Botswana are impeded by production inefficiency, long manufacturing lead time and unoptimized business process. In today's competitive world, productivity is one of the components that lead to successful industrial organizations. Increase in productivity can reduce the cost of work or increase in output. Productivity depends on various operation, such as long lead time, production inefficiencies, waiting, defects and waiting. Value Stream Mapping is a lean tool that visual display where waste occurs in the process. Value stream mapping are often used assess current manufacturing processes as well as create ideal and future state processes. For this research paper, an abattoir was chosen as an industry to work with. This study is to illustrate the implementation of value stream mapping in an abattoir to improve productivity is mainly focused on the production of carcass, that is from the cattles are received from the abattoir building up until now the carcass is delivered to the customer. The focus of this study is to illustrate the implementation of value stream mapping in an abattoir to improve productivity. Current value stream with the help of time study and observations were made to identify bottlenecks in the process. Conclusion and proposed improvements were made based on the data accumulated from observations and time study analysis.

1. Literature Review

This section of the report provides a brief background on the documents, literatures, sources and other documentary reports that were used to solve productivity and production inefficiencies through value stream mapping. Productivity, lean manufacturing and value stream in an abattoir were crucial topics to consider when studying this research area. Value stream mapping is a lean manufacturing tool which originated from Toyota Production System (TPS) and uses