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

[1]Babedi Kufigwa*, [2]Norman Gwangwava, [3]Richard Addo-Tenkorang, [4]Enoch N. Ogunmuyiwa, [5]Albert U. Ude

[1, 2,5] Department of Mechanical, Energy and Industrial Engineering, [4]Department of Chemical, Materials and Metallurgical Engineering, Botswana International University of Science and Technology

Palapye, Botswana +267 74736032

[3]Aalborg University, Department of Materials & Production

Fibigerstræde 16, 9220 Aalborg. Denmark

babedi.kufigwa@studentmail.biust.ac.bw, bdecah@gmail.com

gwangwavan@biust.ac.bw, richardat@m-tech.aau.dk, ogunmuyiwae@biust.ac.bw, udea@biust.ac.bw

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

1. Introduction

This research paper is based on the research that was conducted at Botswana Private Beef Abattoir targeted at implementation of lean manufacturing tools in beef abattoirs. The purpose of this research is to support local companies to improve their productivity and work improvements through implementation of lean manufacturing tools. Some of the lean manufacturing tools that were successfully applied are value stream mapping, 5S, just-in-time, redesigning and optimization of working cells and production layout and control charts. The company receives and detains cattle from local farmers and individuals, which is key to remaining competitive in the industry, but with its apparent challenges affecting efficiency, un-optimized business processes, long manufacturing lead time and undocumented operating procedures. Moreover, these challenges affect the company as it is unable to reach its goals and objectives. The use of lean tools will help reduce waste in the manufacturing process and improve efficiency. The company's primary mandate is to provide slaughter service to butcheries, delivery of carcass which is underpinned by customer service, integrity and support adhering to safety health and environment standard. The company wants to continuously advance and increase its client base through adopting new technologies, evaluation of company marketing strategies and good customer service.

1.1 Background

The case study beef abattoir detains cattle and its plant can hold a capacity of 100 cattle per day. The company is registered in Botswana and is owned by Batswana citizen directors. The Company's Head office is based in Palapye village, which is a rural-urban area and it started its operation in 2014. The plant is equipped with the state of the art slaughtering machinery (Silverwind Botswana, 2015). The abattoir has a prevailing daily slaughtering capacity of about 25 heads of goat or sheep and 70 heads of cattle but has the capacity to slaughter a maximum of 100 beasts daily at full capacity. It has two cold rooms installed in the abattoir with holding volume of 100 tons of meat at a time operating at (-20^0 C) degrees Celsius. Upon formalizing the research with the company some issues were observed and keen for interests, such as the company's business process, supply chain for their products, workplace safety, visuals within the facility, and waste management practices that can be adopted. Abattoirs in Botswana play a big role in Botswana's beef industry. Beef industry is important for Botswana's rural population, and account for an important source of export earnings. It has been emphasized as a strategic sector within the country's economic diversification drive. Botswana's beef sector is at an unfavorable juncture. At the very same, the sector is impeded by structural problems, including an export monopoly and lack of scale, which constrains its commercial potential. Recent years have seen a large reduction in the cattle population and the exit of significant numbers of commercial farms from the sector. Frailties in the country's cattle traceability system prevented access to the important EU market for nineteen months in 2011-2012 and caused large interference in the domestic market due to the resulting surplus (Moro, Chatterji, Hatzipetros, Ghanie, & Tsopito, 2014)

Lean thinking started as a manufacturing method found on the shop floors of Japanese manufacturer Toyota Motor Corporation (Limere & Dora, 2016). Toyota strives for quality cars and focuses on the health of its employees by tenacious devotion to continuous improvement in all the facets of the company (Mukras, 2003). Womack & Jones (2000) stated that there are five principles for achieving lean initiative and minimizing waste. These five principles are specifying a value, identifying the value stream, flow, pull and pursuing perfection. Below in table 1 is a table explaining these five principles:

Table 1: Five principles of lean ((Woman & Jones, 2000)

Specify value	**Specify the value as demanded and defined by the ultimate customer**
Identify the value stream	Value stream contains all actions needed to deliver a product to the final consumer. Identify any non-value adding activity and remove it.
Flow	Make the value-creating steps and processes flow continuously without interruptions.

Pull	Only produce what is needed by the end customer. The customer is the one who pull value from the producer or manufacturer. Prevent inventory stocks as much as possible.
Pursue perfection	The process of reducing space, mistakes, costs and time is a continuous process which is a never-ending story.

Lean has progressively moved from purely manufacturing plants to operations of all kind (Limere & Dora, 2016). The principles are implemented in companies, everywhere and in every sector such as airline maintenance, healthcare, oil production, non-profit, Information Technology industry, publishing, insurance, and government (Corbett, 2009). Beef is the most essential element of the agrifood sector in Botswana (Engelen V. A., Malope, Keyser, & Neven, 2013). Beef is also a key foreign gross income for a large segment of the country's population (Engelen A. V., Malope, Keyser, & Neven, 2017). Productivity has been slacking or dropped over the past years (BEDIA, 2007). The number of cattle entering the value chain is compelled resulting in remarkable overcapacity in the processing sector and low profits. Mulale (2002) stated that existing opportunities in local, regional and international markets are largely unexploited. The author further said that in today's highly competitive and globalizing agrifood sector, including the livestock subsector, the key success factors are quality-based differentiation and supply reliability. Branding is important for quality indication of the product (Steven & Kennan, 2005). Beef sector in Botswana is estimated to account for less than 2% of Botswana's GDP, and 1.5% of its produce (Nkhori, 2004). Botswana cattle industry uses free range and natural farming methods, which ensure seasonal supply and lean beef of highest quality. Botswana's land and its climate are preferred for cattle farming (Mulale K. , 2018).

At the very same, the sector is obstructed by structural problems, which includes export monopoly and lack of scale. These structural constraints hinder commercial competitiveness in abattoirs. Recent years have experienced large reduction in the cattle population and decline in commercial farming. Production, processing and export performance in the sector lags behind its competitors such as Namibia and South Africa. Local meat production has social and environmental benefits as well (Mulale K. , 2002). Botswana's beef exports are highly concentrated in the South African, European and Netherlands, which accounted for 97% of the country's beef exports in 2013. Beef exports are still significantly below the 2010 peak of US$158.6 million (Engelen V. A., Malope, Keyser, & Neven, 2013).

Current problems with major abattoirs

Generally, abattoirs in Botswana are experiencing some problems. Botswana Meat Commission (BMC) as a major abattoir in Botswana is running through losses in every year since then (BEDIA, 2007). There are four possible contributory causes to these losses which are declining prices for beef exports – either absolutely or relative to domestic prices, ex-Botswana costs rising faster than revenue, intra-Botswana costs rising faster than revenue and declining efficiency in BMC (BMC, 2009).

Current situations and issues surrounding major abattoirs from a media report

The ongoing challenges facing the domestic beef sector, in the context of its continued importance to the national economy and livelihoods of Batswana, in 2017 the Minister of Agricultural Development and Food Security had convened a series of consultative meetings to solicit ideas about the future of the beef sub-sector and the role of the Botswana Meat Commission within it (BOPA, 2018). The government of Botswana has adopted measures such as converting Botswana Meat Commission to a limited liability company and be commercialized to achieve operational efficiencies with an appropriate mix of ownership between farmers, legal entities and Government (Goverment of Botswana, 2016). Agricultural sector currently accounts for a relatively small proportion of the country's Gross Domestic Product (GDP) estimated at about 2%, it continues to provide employment and enhanced livelihoods to a large proportion of the rural poor and is deeply woven into our country's history and culture. BOPA (2018) explained that BMC is hampered by challenges such poor and stagnating productivity, weaknesses in support services, seasonal overcapacity and lack of profitability in processing, and under-exploitation of the quality of produce in the export market. Productivity indicators have also declined overtime challenging the competitiveness of our beef industry.

1.2 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. Therefore the content on lean in agriculture is very limited. There is also immaturity of academic papers regarding lean agriculture and its smooth transition from manufacturing to service and to agriculture (Limere & Dora, 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 the profitability through the whole value chain (Limere & Dora, 2016). According to Zokaei & Simons (2006), implementation of lean practices, particularly standard operations and takt time has the significant potential to increase profits and 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. These lean thinking tools that were used are the Five Principles of Lean, VSM and the Seven Wastes Theory. They found an increase in competitiveness by the reduction of waste and the improvement of the food quality (Colgan, Adam, & Topolansky, 2013).

According to the 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 and more efficient utilization and allocation of fixed cost resources to add value. This implies changes to the whole farming system. Study experts also pinpointed that variable inputs such as sprays, feeding and fertilizers are essential to realize the highest quality and produce a potential of land and genetics. This is accomplished through cost/benefit-risk assessment, accurate budgeting and proficient application methods. The allocation of too much grassland to the herd showed there is excess capacity entailing the potential arable farming to yield up to thirty percent (30 %) more of grassland. This will provide a better allocation of resources and augment gross margins per hectare. Furthermore, it is possible to finish bulls one to two months faster at 13-14 months to the same slaughter weight, by commencing full meal diet earlier after weaning. Therefore they reduce demands by nine tons. Other option to be more efficient is rotational grazing in three blocks to achieve extra grassland utilization.

There is also a difficulty in applying lean manufacturing in abattoirs. Measuring the financial value that is being added by lean implementation is a big problem (Limere & Dora, 2016). The author further explains that managers and staff members must be well aware of the five principles of lean to successfully succeed in applying lean. Employees need to be trained too so that they know and they are made aware of to the principles of lean. This can ensure lower breakdowns and higher quality of products.

Simons & Taylor (2007) focused on the value chain involving the red meat industry. These authors yielded a substantial improvement in vertical collaboration. Two key implementation issues were detected which are intercompany association of sub-system methodology in agri-food called Food Value Analysis (FVCA) and organizational stability through time (Simons & Taylor, 2006). This is a consumer value and supply chain analysis method based on tool and techniques from the lean paradigm. Current State Map and key performance characteristics was developed of the whole chain. The results showed that supply time was 185 hours. and from these 185 hours, only 1.4 hours were value adding time (Simons & Taylor, 2006).

Simons & Taylor (2007) identified potential logistics benefits regarding supply chain. They found two key implementation issues which are inter-company alignment of sub-systems for purpose of creating conducive environment and chain organizational stability through time. (Andersson & Eklund, 2012), concluded that applying lean practices and principles in agriculture lead to a more structured and less stressful work environment. Anderson & Eklund (2012, stated that implementation of lean manufacturing tools resulted in a psychological work environment which was more structured and less stressful. Dyrendahl & Granath (2011) specified that the basic principles of lean reduce 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 a fresh produce industry. The authors discovered that

in excess of 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 (Centre, 2007). Voulgarakis, Folinas, Aidonis & Triantafillou (2013) state that VSM analysis is an effective tool to identify waste in the agro-food supply chain.

According to Radnor (2010) lean must not be seen as a strategy but a philosophy. The author further suggests that lean thinking must be viewed on long-term and there is need for continuous improvement. The company needs to become a learning organization thus creating a reflection (Bhasin & Burcher, 2006). Bowen & Youngdahl (2009) discovered that the major difference between lean service and lean manufacturing is that the one you are dealing with the customer on-site whereas the latter does not. Even though implementing lean manufacturing in agriculture and abattoir is a good thing, it brings a lot of changes in the culture and the environment. Bowen & Youngdahl (2009) pinpointed that communication is vital as to 'how' and 'why' lean.. The author further state that lean implementation cannot be successful without continual adjustments as the market change. Bhasin & Burcher (2006) stated that it is important to ensure that the workforce has knowledge about lean thinking and they are aware of waste elimination.

2. Research study methodology

Firstly, a profound literature study was done. The literature review focused on published articles and papers in journal. Papers relating to performance improvements through implementation of lean practices, lean implementation in abattoirs and lean implementation in agriculture or agro-business were reviewed. The research study was conducted using observations, interviews, distribution of questionnaires, surveys, audits and plant tours. Some employees at the company were asked about the production operations and its management. The PDCA problem solving approach was used as a framework to guide the implementation of the research project. This problem solving technique helped in terms of specifying procedures or techniques that are used to identify, select, and analyze information obtained from the case study company, to understand the research problem better. The PDCA framework has four steps which are critical in ensuring the project objectives are achieved, as shown in Figure 1. In each phase of the PDCA, work carried out to achieve the objectives of the project is explained.

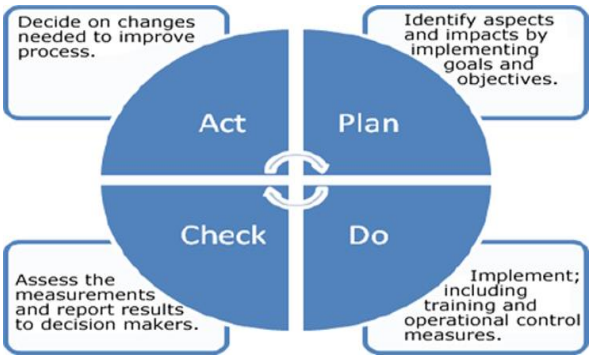

Figure 1: PDCA problem solving technique model retrieved from (Charantimath, 2011)

PLAN Phase

- Identifying and building the existing process using process mapping and SIPOC (Supplier, Input, Process, Output and Customer) paradigm
- Investigated root causes of productivity problems using fishbone analysis diagram
- Identified performance indicators using metrics such as time study and cost-effective analysis
- Observation, interviews was carried out to identify major improvement opportunities in the production process
- Plant tours, document analysis

- Questionnaires

DO Phase

- Identified solutions to address the problems and the implementation of the lean tools such value stream mapping, 5S , work & method study, time & motion study, optimization of production layout and business processes.
- Conducted meetings for pitching up and proposing ways on how to mitigate problems identified
- Conducted training and awareness posters
- Prepared questionnaire to investigates issues more
- Collected data using interviews, company documents, audits, observations and questionnaires
- Reviewed problem areas, documents analysis, and bottlenecks among production, processes, products and systems.

CHECK Phase

- Measured the effectiveness of the implemented lean tools in the DO PHASE using post audits
- Verified whether implemented lean tools solution address intended problems
- Made recommendations and remedial solutions where necessary
- Gathering feedback
- Validating whether implemented lean tools address the intended problems

ACT Phase

- Revised ineffective solutions in terms of cycle time, WIP, on-time delivery, customer satisfaction, and organizational climate
- Made some recommendations and remedial actions where necessary
- Analyzed data using various tools such as Pareto chats diagram, histograms and flowcharts
- Analyzed root cause to problem areas using Ishikawa diagram
- Improved processes and working methods by providing remedial actions, recommendations and suggestions supported with justifications.

3. Research results and findings

Plant tour was done and the process was configured. Some few opportunities were explored that can be used in a research. This includes insufficient visual control in the plant, efficiency, un-optimized business processes, long manufacturing lead time and undocumented standard operating procedures

3.1. Process

As the plant was toured, a high process level paradigm was identified, also known as SIPOC (supplier, Input, Process, Output and Customer). This is shown in Table 1.

Table 1: SIPOC Diagram

Supplier	Input	Process	Output	Customers
Farmers	Cattle of any size	Cattle or small stock received at the gate	Unprocessed beef	Local butchers
Individuals	Machinery	Lairaging cattle in a kraal	offal's	supermarkets

	Labour	Ante-mortem inspection by the department of veterinary service personnel	hides	
		Stunning		
		Halaal is done		
		Hoisting		
		Bleeding		
		Dressing		
		Splitting i.e offal, head and carcass separation		
		Ante-mortem inspection by Department of Veterinary Services		
		Stamping i.e the establishment stamp that is issued by the Department of Veterinary Services(DVS)		
		Weighing		
		Invoicing		
		Loading		

A process was identified to find opportunities that can be used or areas that can be of interest in line with research title. From the process, cattle or small stock is received a day before slaughter at the receival gate by the security guard. As the cattle are received, livestock documents are checked. Information checked is the inspection clearance from the police and inspection documents from department of veterinary services. Animals without the necessary documents are taken back to the farmers and are not allowed to enter the facility. Livestock are then taken to a penning kraal where they are housed according to the housing capacity of the kraal. In peening kraal, cattle or small stock are given identification through branding, and then there is an ante-mortem inspection that is done by the Department of Veterinary Services (DVS). Checking of documents and recording the information in the system for cross-checking and verification. After the all documents have passed, they are then taken to the stunning box. Stunning takes place, and then a halaal is done. After halaal is done, then hoisting takes place for moving the slaughtered livestock in a production line. The company uses product layout for its production. Dressing takes place using skin hidder machine, and then followed by tagging the carcass for identification; the splitting of the carcass takes place separating head, and offal's. The DVS inspection (often called post-mortem inspection) takes place after splitting has been done. The carcass is inspected for disease such as bovine measles and others. If the carcass has this measles, it is then detained in four days in a chiller, but if the carcass does not have any disease condition, it passes. Then weighing takes place, and then it is invoiced and then finally loaded for customer delivery. The process is illustrated in Figure 2.

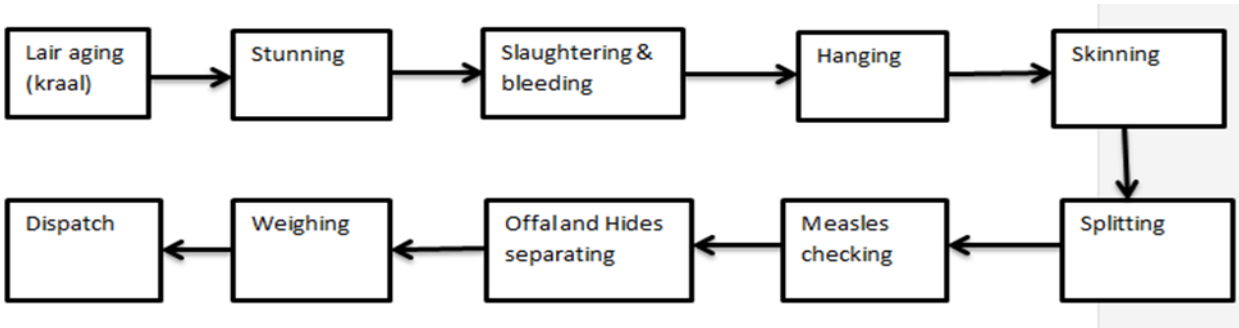

Figure 2: Process of Botswana Private Beef Abattoir

Furthermore a detailed business process of Botswana Private Beef Abattoir was identified. Below in Figure 3 is an illustration of the business process.

3.2 Identified areas of interest from plant tour, observation and interview conducted

The following areas of interest were identified;

i. Use of production charts to analyze production
ii. Effective way of dealing with customer complaints
iii. Workplace improvements using 5S
iv. Undocumented operating procedures
v. Unaudited production and business processes

3.3 Steps taken to address the problem

The research was conducted following the Plan, Do, Check and Act methodology phase, and all the steps have been followed to address the issues that the company is facing. Interviews, plant tours, audits, trainings, process mapping, and process performance, recommendations, literature review, suggestions, questionnaires, 5S implementation, value stream mapping, process documentation, were measured, prepared, implemented to address the issues identified. Table 2 below summarizes the lean tools that were used to rectify the above issues, response, challenges and their status quo.

Table 2: Summation of research project action plan implementation

Problem issues	Lean tools used	Description	Status quo	Challenges
Long manufacturing lead time	-Value stream mapping -Process mapping and workflows -Work study -Method study -Takt-time -Time study -Method study -Work study	-It was identified that there is long manufacturing lead time, and delays are upon the receival of the animals at the gate, when they are offloaded to be lairanged, ineffective data capture that is used for verification inspection by the DVS, to inspect whether all documents and	-Suggestion were made as to assign a specific personnel who offloads the animals -Another suggestion was to do in-house training for their IT technician who will be working hand in hand with the DVS	-Longtime response from the management side -Lack of funds to implement suggested solutions -Communication barrier -Expensive running costs which hinders some implementation solution

		permits have been cleared		
Undocumented operating procedures	-Standardized work -Process documentation	They were no documented operating procedures	Operating are now available and in use	-Time constraint -Some employees were feeling intimidated
Unaudited production and business processes	-Process documentation	-Like it was said, there were no documented procedures, and it was difficult to audit an undocumented process	-The suggestion was made that the business and production processes should be audited at least three times in a year, after three-four months in conjunction with DVS since they are the one responsible for auditing the production process	- Scheduling of meeting with DVS inspectors to know the format they expect when auditing production process
Insufficient workplace improvements	5S audit checklist 5S team Council Training Facility layout design	-There was no signage, labelling of equipment, floor marking, improper display of material handling equipment, production charts, notice board, and markings	-5S implementation was partial successfully -The suggestion was made as to the priority areas for improvements -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 suggestion was discarded -High costs -Limited time to make those all improvements in one year -Delay in response from the management
The ineffective way of dealing with customer complaints	5S	-There was no proper channel of customer complaints -There were no receptions to deliver or dealing with customer complaints	-The suggestion was made to the company to hire a receptionist, Safety Health Officer(SHE) responsible for handling customer complaints and be regularly in the helping desk table -The suggestion of a box that customers can place their complaints in and the box monitored by the assigned personnel	-Proper justification as to why they need to have these two people(receptionist and SHE officer)

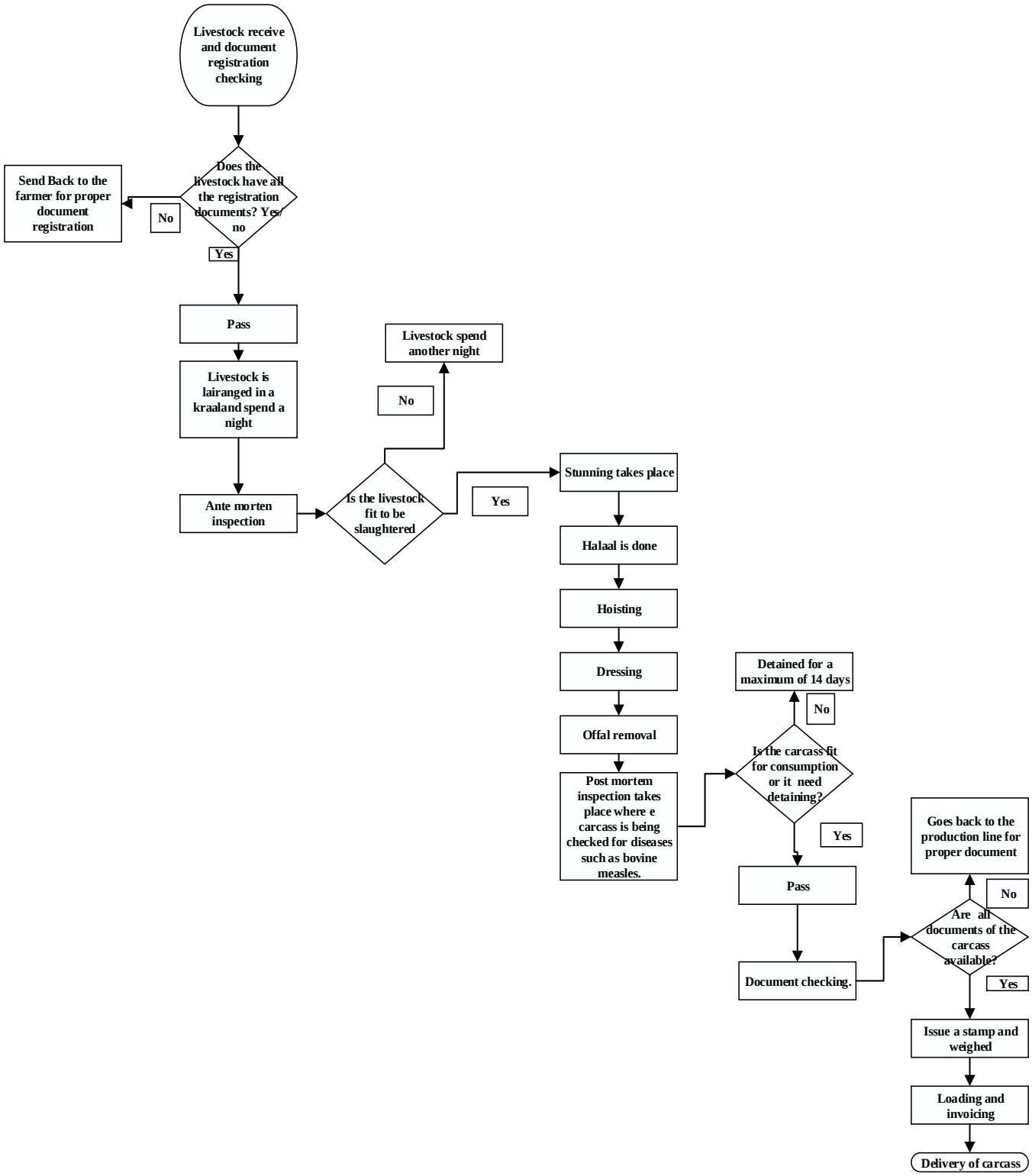

Figure 3: Business process of Botswana Private Abattoir

4. Conclusion

Based on the results of lean manufacturing tools, philosophies and practices results, responses and challenges, it is very challenging to successfully implement lean practices, tools and philosophies in abattoirs. These challenges factors are due to the fluctuating supply of cattle from local farmers, structural problems, export monopoly commercial potential constraints, declining markets of abattoir industry in Botswana, declining market of the beef industry in Botswana's export to European Union. Lean practices (principally takt-time, standard operations, value stream mapping, work study, time study and 5S) have demonstrated potential improvements. These demonstrated improved working methods and safety awareness in the facility in comparison with before and after lean implementation results. Further work is planned to understand the economic cost-effective saving analysis of utilities compared to installation of solar power in Botswana Private Beef Abattoir.

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Biography

Babedi Kufigwa received his Bachelor's degree in Industrial Engineering in 2017 from the University of Botswana, (Botswana). Currently he is pursuing his Masters in Industrial and Manufacturing Engineering at the Faculty of Mechanical, Energy and Industrial Engineering at Botswana International University of Science & Technology, (BIUST). He is also doing a research with Botswana Private Beef Abattoir, Palapye (Botswana), titled, "Design, Optimization & Implementation of lean manufacturing tools in an abattoir: A case study of Botswana Private Beef

Abattoir". His main research areas are business process improvements, process optimization, productivity improvement initiatives and developing cost effective measures for improving efficiency, processes, production in manufacturing, businesses, industries, production fields and service industries. He is a member of Chartered Institute of Procurement and Supply, (CIPS) with British council Board.

Norman Gwangwava is a professional Engineer with experience from industry and academia. He is currently a lecturer at the Botswana International University of Science and Technology (BIUST), department of Mechanical, Energy and Industrial Engineering. He has presented and published many research papers at conferences and refereed journals. Research interests are in; Reconfigurable Manufacturing Systems (RMS), Cyber-Physical Production Systems (CPS), Collaborative Product Design and Closed Loop Life-Cycle Systems, Manufacturing Information and Database Systems. He holds a PhD in Industrial Engineering from Tshwane University of Technology, South Africa and a Master of Engineering in Manufacturing Systems and Operations Management from the National University of Science and Technology, Zimbabwe. He is a member of the SAIIE-*ZA* and ZIE-*ZW*.

Enoch N Ogunmuyiwa received both his PhD and MSc(Eng) in Materials and Metallurgical Engineering in 2013 and 2009 from the University of Witwatersrand, South Africa respectively. He obtained his BEng degree in Metallurgical and Materials Engineering from the Federal University of Science and Technology, Akure (FUTA) Nigeria, in 2005. He is currently lecturing at the Botswana International University of Science and Technology (BIUST) in Botswana. His research interests revolve around the use of powder metallurgy technique to develop engineering materials from the production processes to failure of components. The research involves the production and/or development of new and existing materials vis-à-vis the design stage through synthesis and development, characterizing and testing. The design stage utilizes the structure-property relationship that determines the performance of a material in service. He is also currently and actively engaged in several research projects in understanding relationships between microstructure and properties in different industrial manufacturing processes. He seeks more in understanding the structure-property-processing relationship in materials especially for sustainability.

Richard Addo-Tenkorang is a professional Engineer with several years standing. He is currently a Postdoc on the Manufacturing Academy of Denmark (MADE Programme) – MADE Digital at Aalborg University, Denmark. At the Centre for Industrial Production & Department of Material & Production. He holds a (DSc.-Tech) in Industrial Engineering and Management, PGCE in Higher Education Pedagogy, MSc. in Digital Enterprise Management, B'Eng (Hons) in Mechanical Engineering and (HND) in Mechanical Engineering. His research interests are in the areas of enterprise supply-chain management, digital manufacturing – 3D printing, IoT, Industry 4.0, supply-chain BigData management, etc. and has published extensively on internationally renowned platforms in these areas. He is an active member of IET, IRED, CSCMP & IAENG.

Albert Uchenna Ude received both his MEng and PhD in Mechanical and Materials Engineering in 2006 and 2011respectively from The National University of Malaysia, Bangi Malaysia. He is currently lecturing at the Botswana International University of Science and Technology (BIUST) Palapye, Botswana. His research interests are more in Non-metallic Materials, and Renewable Energy Applications.