IMPROVEMENT OF WAREHOUSING PROCESSES BY APPLYING LEAN TOOLS: THEORETICAL FOUNDATIONS

Jane Wambui GATUNDU, Vytautas Magnus Agricultural Academy, Faculty of Bioeconomy Development, email: jane.wambui.gatundu@vdu.lt

Summary

The article discusses the improvement of warehousing processes by applying lean tools. A brief history shows how people like Fredric Taylor, Henry Ford and Taiichi Ohno contributed towards the lean concept known today. The seven types of wastes (Muda): overproduction, defects, waiting, unnecessary motion, inventory, transportation and over processing identified by Ohno point areas to investigate and determine the presence or absence of waste. The five lean principles: identify value, value stream, flow, establish pull, and seek perfection, act as a guide when implementing lean tools to any warehousing processes. The lean tools discussed in the article are Value Stream Mapping (VSM), 5s, Kanban and Kaizen. The research was conducted by analysing published literature sources. As per the researchers' results, applying lean tools in warehousing processes improves productivity, creates safer working environments, motivates employees, reduces lead time and improves customer service.

Keywords: warehousing processes, lean tools, Muda, value stream mapping, kanban, kaizen

Introduction

Warehouses are temporal storage locations that hold inventories and match them to demand; depending on the purpose of the facility, it could be raw materials, work-in-progress or finished goods. The four major warehousing processes are receiving, storage, picking and dispatch. Implementing these processes largely depends on factors such as the purpose of the warehouse, its location, and the size of orders (Perkumienė et al., 2022). Warehouses were traditionally used for storage and viewed as cost centres that did not add value to the businesses. Over time, they have evolved and are now seen as a strategic advantage (Geest et al., 2022). Globalization has caused rapid changes in the market, forcing businesses to adapt to the ever-changing needs of their customers, who continuously demand high-quality products at low prices and shorter delivery times (Hassan, et al., 2023). Efficient warehouses give businesses a competitive advantage by reducing operating costs and supporting quick, accurate orders with a short lead time. It also cushions a business against sudden market crises such as the Bullwhip or Ripple effect. Mismanagement of warehousing processes will negatively affect a business's returns by generating inventory waste and creating inventory breaks that lead to loss of sales and customers (Marziali, et al., 2021). As such, challenges in warehousing processes must be mitigated or eliminated as they directly affect the level of customer service and the cost of the supply chain.

Following the successful application of lean in manufacturing, the idea of lean has significantly evolved and now has become a model applied in many industries and in different business processes. Due to its diverse applications, lean literature is fragmented and requires deeper analysis (Danese et al., 2018), analysing the recent literature on applications of lean in warehousing is a step towards closing the gap and making more contributions. Lean labels any non-value-adding activities in a system as waste and seeks to eliminate these activities if they are not necessary for running the business. By managing the waste areas in a warehouse, productivity is improved, warehouse processes become more efficient, and value is added to customers. The 5S, Kanban, and Kaizen, are some of the lean tools applied in warehouse management. The lean principles include value identification, value streaming, flow, establishing the pull, and seeking perfection.

Research aim: To demonstrate the improvement possibilities of warehousing processes by applying lean tools.

Objectives:

1. To examine lean tools and how they are applied in warehousing processes
2. To identify the benefits of applying lean tools in warehousing processes

Research object and methods

Research object - warehousing processes improvement by applying lean tools.

The search for scientific literature was carried out using Scopus, MDPI and Google Scholar databases. The following keyword combinations in English were selected for the search: Warehousing processes, Lean, Lean principles, Lean tools, warehouse optimization, wastes in warehousing, 5s, Kanban and Kaizen. The year of publication of the articles had to cover 2014-2024. period. Full-text articles were used for analysis. Out of 30 found literature sources, 19 articles met the established criteria and were included in the systematic review. The results of the analysis are based on the content of the examined text. The analysis gives a history of the lean concept and its principles, how lean tools are applied in warehousing processes and the benefits derived from lean warehousing.

Research results and discussion

The History and Overview of the Lean Concept

Frederick Winslow Taylor, commonly referred to as the father of modern management, taught about the importance of work standardization in the 20th century. He advocated replacing old practices with new ones that eliminated non-value work activities. Frank Gilbreth and Lilian Gilbreth valued efficiency; in their management theory, they devised the best way to carry out a task (Dilanthi , 2015). Establishing standard procedures and arranging workspaces in a way that reduces the number of motions required to perform a task.

Henry Ford, an automaker in the 20th century, applied Frederick Winslow Taylor's management theory in his manufacturing company. He worked to reduce waste in the manufacturing process by allocating workers tasks that suited their capabilities, reducing the number of tasks an operator was required to perform, and keeping heavy motor parts stationary while the lighter parts were moved to reduce motion waste. He examined workers' performance, and when they did not perform, he provided more instruction and ordered supervision. Workers were given an avenue to contribute to improving methods or implementations (Tomac et al., 2019). He introduced Just in Time (JIT) to ensure that he received the required amount of materials according to the demand. In Ford's production line, all things were produced at the same rate.

After the 2nd world War, Toyota's Taiichi Ohno and Eiji Toyoda visited the automobile industry in the USA, where they observed and learned from the industry. Upon returning to Japan, Taiichi Ohno applied and improved on what he had learned to develop the Toyota Production System (TPS) over the years. The TPS is based on two pillars Just-In-Time (JIT) and Jidoka (Anoop & Gogi, 2020). JIT involves producing what is needed, when needed and in the right quantity. Any product produced and not in demand is considered wasteful, as it would require space and labour that could be used elsewhere and also cause congestion due to overproduction. Jidoka is intelligent automation where machines can detect errors and stop producing automatically, regulating the quality.

As part of TPS, Ohno developed three categories of waste: Muda for process wastes, Mura for irregularity in product and Muri for unnecessary operator strain. Following a successful implementation of the TPS, lean manufacturing has been adapted in many industries and applied to other businesses. Muda has been used in warehousing processes to eliminate waste; waste is any activity in manufacturing or processes that does not add value. Organizations have three types of activities: value-adding activities, non-value-adding activities that are necessary and non-value activities with zero value (Faulkner & Badurdeen, 2014). Ohno identified the seven wastes or Muda - overproduction, defects, waiting, unnecessary motion, inventory, transportation and overprocessing (Altarazi & Abushaikha, 2019):

1. Overproduction in the warehouse occurs when excess inventory is received. The extra stock takes up more space, which could be used to store other selling items, leading to longer lead times and reduced customer service. It also increases the inventory costs as more labour and space is needed.
2. Defects in waste in warehousing occur when picked orders do not match the customers' requirements.
3. Waiting is the waste that occurs when inventory movement stops and there is no activity in the warehouse. This happens when inventory is not received in time, over staffing, machine downtime, and having an inflexible staff.
4. Unnecessary motion waste occurs when the warehouse staffs make redundant movements during their duties. This could be due to poor warehouse layout, disorganized work areas, and unclear storage locations.
5. Inventory waste occurs when an unnecessary increase of inventories could be safety stock, goods with low demand or stored damaged goods. It results in poor utilization of the warehouse, where items in demand may not be available when customers demand (Anoop & Gogi, 2020).
6. Transportation waste occurs when inventory or machinery in the warehouse is moved unnecessarily. It could be due to poor warehouse layouts, poor route plans, and a disorganized warehouse.
7. Over-processing waste occurs when unnecessary activities that do not add value to the product or improve customer service are incorporated into the warehouse.

Applying Lean Principles and Tools in Warehousing Processes

Lean Principles

The five crucial lean principles in warehousing are value identification, value streaming, flow, establishing the pull, and seeking perfection (Pauluk & Oláh, 2017):

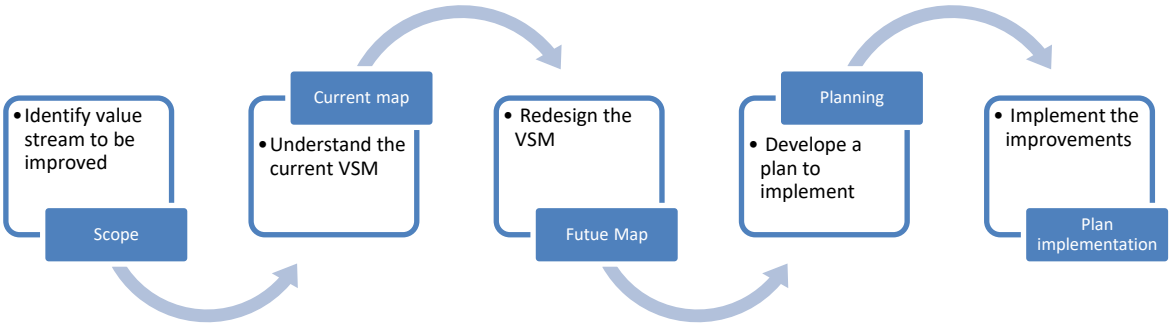
1. Identifying value refers to viewing value from the customers' point of view, which is the amount customers are willing to pay for a product or service. Consumers determine value and can only understand it if it is perceived from their perspective.

2. The value stream creates a map of all processes to identify wastes. All methods are investigated, and any non-value-adding activities that are not necessary are eliminated. The Value Stream map (VSM) is a lean tool used to create and present a visual guide to all the processes from the beginning to the end (Langstrand, 2016). In warehousing, VSM visualizes in detail the movement of inventory from receiving, storage, and picking to dispatching. It identifies wastes and inefficiencies even when they are hard to detect by integrating the inventory, information, and timeline. The VSM process has five steps: preparation/scope, drawing the current map, drawing a future map, planning and implementing improvement.

3. The flow starts when inventory is received in the warehouse through all major and minor processes to when it is dispatched. Continuous flow in warehouses reduces congestion and delays, allowing for quicker picking with minimal errors, thus shortening the lead time.

4. Establishing the pull involve adjustments to respond to consumer demand.

5. Seek perfection: Once the other principles are implemented, they should be continuously evaluated and improved (Phogat, 2013). In warehousing, perfection is delivering the right quantity at the correct time and at a reasonable price.



Source: Langstrand, 2016

Figure 1. VSM processes

Lean Tools

The analysis of different scientific literature revealed a wide range of lean tools, discussed in this article are those that present the main and most applicable tools for improvement of warehousing processes. They include, 5s, Kanban and Kaizen.

5s. The concept of 5s aims to create working spaces that are clean, organized and safe. 5s play a critical role as it enhances efficiency and productivity and improves employee motivation in any business. This lean tool consists of five steps which are Seiri (sort), Seiton (set), Seiso (shine), Seiketsu (standardize) and Shitsuke (sustain)

- Seiri (sort): Sort refers to separating things by asking why, when and how often they are needed. Each major warehousing process has its own activities. Sorting can be used to examine each activity, and those found to be unnecessary are marked to be removed, eliminating the over-processing waste. Different tools and materials are used throughout the warehousing processes; it is important that they are sorted and classified by examining their conditions and usefulness. Tools and safe materials can be tagged green to notify employees that they are safe to use, and damaged ones are tagged red as a warning and marked for removal. At the receiving dock, inventory is sorted and classified according to the type of product and its condition; quality products may be tagged blue or green and those with defects red.
- Seiton (set): The second step is where the classified items are put in their respective locations. The tools and materials tagged green are organized in the specific areas used to ensure that they are easily accessible, reducing transport and motion wastes (Kabiesz & Bartnicka, 2019). Inventory tagged blue or green is stored in designated locations; big and heavy items are stored in low locations and closer to the loading deck. Storage areas are by marking isles, labelling shelves, and having route plans. If done properly, tracking and picking orders is done efficiently and quickly with minimal errors and while reducing customer waiting periods.
- Seiso (shine): Shine is the third step that involves cleaning the working area. Tools and materials tagged red are removed from the work floor, reclaiming more space and lowering the risks of injury or inventory damage. Inventory tagged red is placed in an area for defects, eliminating the chances of picking them up and allowing proper documentation of damages. When the working areas are clean, it is easy to detect any problems and repairs. Disorganized working areas increase the risk of injury and inventory damage efficiency and adequate employees.
- Seiketsu (standardize): The fourth step is standardization and requires correct implementation and maintenance of the first three steps: sort, set and shine (Kabiesz & Bartnicka, 2019). Standardization eliminates over-processing waste by doing away with activities that are not needed. With a clear guide, employees can continue with the practices in sort, set and shine and over time, their continued participation makes it easier for them to complete tasks quickly and efficiently. Quick and efficient translates to reduced warehouse costs and better services.
- Shitsuke (sustain): The fifth and last step involves continuous support and communication with workers to encourage them to maintain all the improvements made in the first four steps.

Kanban. Kanban is a Japanese term that roughly translates to “visual board” or “signboard” Ohno introduced it in the 1950s to implement Just-In-Time during the development of TPS (Sapry, et al., 2020). Kanban is a scheduling system that controls manufacturing and inventory and improves the flow of information within the supply chain. It points out when inventory drops, allowing businesses to restock in time. In the past, Kanban used coloured signs to check and maintain inventory, which is no longer reliable due to rapid changes in business practices and the market. It has evolved, and electronic Kanban utilizes information from scanned barcodes to monitor inventory movement in the warehouses, alerting those responsible when replenishment is needed (Sapry). Overproduction waste is eliminated as ordering deliveries to the warehouse are requested once a product inventory goes down. Inventory waste is prevented as only products that are in demand are replenished in the warehouse, maintaining optimum inventory levels and reducing overall warehouse costs (Ali et al., 2020). Kanban also advocates for proper inventory handling and reduction of distance travelled, reducing transportation waste.

Kaizen. Kaizen is based on Japanese tradition that seeks small and incremental continuous improvement. Masaaki Imai introduced it as a management concept that improves workplaces and eliminates unnecessary hard work and waste in processes. (Prošić, 2011). Significant features of Kaizen are continuous improvement of quality and productivity,

collaboration and participation of employees (Tekin et al., 2019). When employees are motivated and involved, their morale increases, and they find their tasks easier to perform, resulting in a low turnover and maintenance of a highly knowledgeable workforce. Kaizen can be implemented using the PDCA (plan, do, check and act) cycle. The plan refers to identifying the challenge and planning how to solve it, Do is the execution stage, Check refers to analysing the results, and Act is the implementation of the solution. If the results are unsatisfactory, the Plan stage is initiated again and improved, creating a continuous cycle of improvement. Kaizen can be implemented alongside VSM, 5s, Kanban and other lean practices.

Benefits of Applying the Lean Concept in Warehousing

The use lean in warehouses improves efficiency and productivity. As a result, there are minimum errors in order picking and shorter lead times, allowing customers to get their orders quicker. Stock integrity ensures that proper levels are maintained, customer demands can be met, and sales opportunities are not lost (Altarazi & Abushaikha, 2019). The table below results following the implementation of lean in warehousing processes.

Table 1. Results of Implementing Lean in Warehouses

Study	Area	Benefits
Cook et al. (2005)	Warehousing	71% decrease in inbound cycle time, 76% decrease in inventory levels, required storage space decreased by 51%
Dehdari (2013)	Warehousing	Increase warehouse productivity by at least 5%
Demeter and Matyusz (2011) M	Manufacturing	35,8% reduction of inventory days of raw materials, 33,8% reduction of inventory days of work in progress, 46,9% reduction of inventory days of finished goods
ACA et al. (2012)	Warehousing	9,34% improvement in overall warehouse productivity
Shah and Ward (2003)	Manufacturing	Positive influence on scrap costs, cycle time, lead-time, labour productivity and manufacturing cost
Swank (2003)	Warehousing and services	60% reduction in response time, 28% reduction in labour costs and 40% reduction of reissues due to errors.
Yang et al. (2011)	Manufacturing	Significant effect of $\beta = 0{,}394$ on market performance and $\beta = 0{,}283$ on financial performance

Source: according to (Visser, 2014)

Conclusions

Warehouses now play a great role in determining the profitability of a business, and without a proper management businesses tend to suffer high warehouse operation costs, shocks from the market, loss of sales, and customers. In the modern world customers' needs drives the direction a business takes, lean principles calls for viewing value from a customer's point, creating a value stream map that identifies wastes, maintaining a continuous flow that supports optimization in the warehouse, only responding to demand eliminating problems such as congestion and high holding costs. A continuous improvement will ensure that the right products are delivered to the right location in time. As researchers observed, the 5s concept creates a safer working environment, easy detection of damaged inventory and tools, employees receive more training and are appreciated, processes are standardized, and as a result, the warehouse is run more efficiently, productivity increases, minimal errors and damages and increased customer service (Pauluk & Oláh, 2017). The use of Kanban in warehouses reduces operational costs, eliminates overproduction, enables optimal inventory levels and improves the reaction to demand fluctuations (Ali et al., 2020). Kaizen views challenges as opportunities to improve; it detects the problems and reports and minimizes or eliminates them by taking processes and rebuilding them to match quality (Prošić, 2011). One or more lean tools can be applied simultaneously to improve efficiency and eliminate waste in the warehouse. Following the literature review lean is a significant tool that can be applied in warehousing processes to minimize cost, eliminate waste, improve employee morale, satisfy customer needs and improve the business profitability.

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