ISBN: 978-628-95207-8-1. ISSN: 2414-6390. Digital Object Identifier: 10.18687/LACCEI2024.1.1.1805

Storage management model based on Lean Warehouse Management and Systematic Layout Planning

Emma Marcelo-Alfaro, Bsc[1], Santiago Rodríguez-Escobedo, Bsc[1], Rosa Moore-Torres, Msc[1] and Carlos Torres, Msc[1]
[1]Ingeniería de Gestión Empresarial, Universidad Peruana de Ciencias Aplicadas, Lima, Perú,
u201414846@upc.edu.pe, u20151b436@upc.edu.pe, pcgekmoo@upc.edu.pe, and carlos.torres@upc.pe

Abstract– ***The logistics and storage sector in Peru has experienced significant growth due to increased imports and the trend among companies to outsource their storage processes. This article addresses the challenge of enhancing warehouse efficiency, particularly in the picking and location processes, through a warehouse management model. The methodology employed includes a company diagnosis, Value Stream Mapping, the 5S methodology (a Lean Warehouse Management tool), and Systematic Layout Planning. These approaches aim to improve inventory management and human resource utilization to reduce late order rates. This research demonstrates the application of Lean tools in warehouse management, an innovative concept in Peru, with positive outcomes: reducing the late order rate from 14.69% to 3.71%. Moreover, it proves economically viable with a positive net present value (NPV) of S/. 12,659 and an internal rate of return (IRR) of 45.03%. This study contributes to promoting research for enhancing warehouse processes in Peru, addressing a gap in scientific literature on this topic.***

Keywords-- Warehouses, Lean Warehouse, VSM, 5S, SLP

Digital Object Identifier: (only for full papers, inserted by LACCEI).
ISSN, ISBN: (to be inserted by LACCEI).
DO NOT REMOVE

Storage management model based on Lean Warehouse Management and Systematic Layout Planning

Emma Marcelo-Alfaro, Bsc[1], Santiago Rodríguez-Escobedo, Bsc[1], Rosa Moore-Torres, Msc[1] and Carlos Torres, Msc[1]
[1]Ingeniería de Gestión Empresarial, Universidad Peruana de Ciencias Aplicadas, Lima, Perú,
u201414846@upc.edu.pe, u20151b436@upc.edu.pe, pcgekmoo@upc.edu.pe, and carlos.torres@upc.pe

Abstract*– The logistics and storage sector in Peru has experienced significant growth due to increased imports and the trend among companies to outsource their storage processes. This article addresses the challenge of enhancing warehouse efficiency, particularly in the picking and location processes, through a warehouse management model. The methodology employed includes a company diagnosis, Value Stream Mapping, the 5S methodology (a Lean Warehouse Management tool), and Systematic Layout Planning. These approaches aim to improve inventory management and human resource utilization to reduce late order rates. This research demonstrates the application of Lean tools in warehouse management, an innovative concept in Peru, with positive outcomes: reducing the late order rate from 14.69% to 3.71%. Moreover, it proves economically viable with a positive net present value (NPV) of S/. 12,659 and an internal rate of return (IRR) of 45.03%. This study contributes to promoting research for enhancing warehouse processes in Peru, addressing a gap in scientific literature on this topic.

Keywords-- Warehouses, Lean Warehouse, VSM, 5S, SLP

INTRODUCTION

In the logistics sector, import, storage and distribution processes are developed, so it is crucial to investigate the background of the import market, which has had a growth of 240% due to the popularization of electronic purchases. In 2020 to 2021, according to the Peruvian Chamber of Electronic Commerce, this increase caused companies from other sectors to look for new strategies to optimize the storage and distribution of their products, concluding that outsourcing would be more efficient, whether partially or completely [1]. However, the performance of the sector showed a drop in its activities of 5.9% compared to 2021 [2] and the production index of the storage subsector decreased by 7.97% during 2020 and 2021 [3].

Therefore, the importance of the problem was evident in the disparity between market growth and the poor performance of that sector. The reason for this was determined according to the types of warehouses in Peru, where type A, which represents 62% of the companies, are less than 15 years old and, although they have the appropriate infrastructure, they do not have the experience or the proper management. to cover this demand and those of type B, which represent 38%, are more than 15 years old and are correctly managed but have poor infrastructure [1]. In this context, a targeted contribution is proposed: enhancing storage management tailored to type A warehouses, aiming to resolve issues such as inefficient distribution, warehouse disorganization, and operator specialization deficits. Previous research has addressed similar issues, exemplified Ref. [4], who employed techniques like Lean Warehouse Management and its associated tools to boost productivity, minimize downtime, and streamline operations. Through methods such as Value Stream Mapping (VSM) and 5'S implementation, they achieved a 22% reduction in warehouse travel distances and optimized product picking processes, resulting in improved order delivery times and increased sales. It's important to note that the implementation context differs from the case presented in this scientific article, as the company in question operates within the manufacturing sector despite having warehouse operations. Additionally, Ref. [5] demonstrated the successful application of Lean Warehouse principles in the sugar industry, focusing on reducing non-value-added costs. Through methods like Value Stream Mapping (VSM) and the ECRS (Eliminate, Combine, Reorganize, Simplify) framework, they streamlined processes, reduced downtime, and enhanced productivity, leading to a 36% reduction in warehouse management cycle time and a 48% decrease in worker workload. While their specific activities and company model differ from the current study's context, the success of Lean Warehouse principles in addressing storage challenges is evident. Additionally, Ref. [6] proposed an algorithm aimed at efficiently identifying operational areas and corresponding spaces required for product storage within a defined timeframe. Their research addressed issues stemming from poor space allocation in warehouses, leading to high storage costs and inefficient production processes. Although their approach utilized a technological tool to tackle these challenges, the algorithm's design was tailored to a company model different from the context of the current study. Despite this, it is evident that their proposal could effectively resolve storage issues within the targeted company. Moreover, the scarcity of cases employing the proposed tools, particularly Lean Warehouse Management, underscores the significance of the present research, which investigates the application of Lean tools within an uncommon context.

The main motivation of this research was to create a warehouse management model that helps MSEs (micro and small enterprise) belonging to the logistics and storage sector to establish a basis for improving their management by implementing Lean Warehouse Management and Systematic Layout Planning (SLP). Furthermore, it is expected that, with the realization of this model, more research projects will

Digital Object Identifier: (only for full papers, inserted by LACCEI).
ISSN, ISBN: (to be inserted by LACCEI).
DO NOT REMOVE

develop the application of Lean Warehouse for warehouses in Peru. Based on this, a MSE warehouse company was investigated that needed to reduce its rate of late orders, which current percentage is 15%, since the high-quality standards of its supplier require that this be reduced to 6%. Likewise, it was determined that the problem had an annual monetary impact on the company of S/ 45,512, leading to a net profit of S/ -3,692 in 2021. That is why, this research was used to provide a solution to the high rate of late orders, specifically intervening in the merchandise storage and picking processes. Therefore, in the proposal, two Lean Warehouse Management tools were used, the 5'S methodology to make the aforementioned processes more productive, ensuring a philosophy of total quality in the organization, since it seeks to obtain processes with zero accidents, defects, delays and waste under a structured operation [7], and VSM to visualize the warehouse process flow from a holistic point of view with the purpose of establishing a strategic direction when implementing improvements and validating the proposal to be made [8]. In addition, the SLP tool was used to study all the components that are part of the company's facilities and develop a design that allows efficient use of resources and work areas with the objective of improving the flow of products and reducing related costs. with the merchandise location and picking processes [9].

Finally, this scientific article consists of five main chapters. The first chapter, "State of the Art," provides a theoretical framework of fundamental concepts, categorized by typology, developed in the research. It draws upon articles from indexed journals authored by experts in Lean Warehouse Management or related tools. In the second chapter, "Contribution," implementation flowcharts of the improvement proposal, model design, tool execution, and monitoring of performance indicators are elaborated upon. The third chapter, "Validation," presents results derived from data collected post-implementation in the company, aimed at confirming the proposal's effectiveness. In the fourth chapter, "Argumentation," a critical review of information presented in preceding chapters is conducted. Finally, in the fifth and concluding chapter, "Conclusions," key research findings are highlighted, and subsequent company outcomes are analyzed.

STATE OF THE ART

Warehouse Management:

Efficient resource utilization during merchandise reception, storage, and distribution is crucial for achieving organizational objectives, as it enables adaptation to unexpected market changes and crises [10]. In this research, the integration of Lean philosophy with warehouse management led to the application of Lean Warehouse Management. This approach aims to minimize waste—such as delays and reprocessing—across the entire supply chain, encompassing processes before, during, and after [11]. Consequently, Lean warehouse management offers warehouse companies the assurance of efficient order dispatch and heightened productivity within the area. It prioritizes enhancements in organizational, operational, and human aspects associated with storage [12].

In terms of results, it's feasible to reduce costs associated with merchandise handling by 1% to 5% [13]. Moreover, shelf storage can increase by up to 60%, while the occurrence of merchandise being stored outside its designated location due to organizational lapses is eradicated [14].

Value Stream Mapping (VSM):

Being first developed in the year 1980 by “Toyota” [15], Value Stream Mapping (VSM) is a simplified tool that helps an organization to identify all the resources wasted during the production flow, analyze its current performance through a mapping of its existing state to recognize possible ways of implementing tools belonging to “Lean Manufacturing” and develop improvement action plans that will be reflected in a future state map [16]. In other words, the VSM is defined as a visual tool that allows an easy understanding of the investigated process to identify opportunities for improvement through the elimination of waste that affects operational efficiency [17]. It should be noted that, among various Lean tools, VSM has become one of the most used in both industrial and service companies, since it offers a holistic vision of manufacturing processes, thus developing through 4 basic stages: recognition of product or object of analysis, creation of a current map, evaluation of said diagram and identification of existing problems and construction of a future map [18].

Likewise, in terms of manufacturing, with the execution of the VSM a notable improvement is obtained in the production area of up to 6%, as well as obtaining a visualization of each process to understand production performance [19]. In addition, a reduction of 52% and 45% is achieved in the delivery time of finished products and in productivity, respectively, thus allowing the percentage of added value to increase up to 71%, the percentage of non-value-added decreases to 29%. % and an increase in the average performance of operators by 26% [20]. With respect to a focus on warehouse management, a correctly organized and clean area design is achieved, an improvement in the productivity of logistics operations and a reduction in the travel distance traveled by operators by 88% [21]. In addition, a reduction of up to 59 hours of order delivery and an increase to 76% of its success rate is achieved [22].

5'S Methodology:

Method created and devised in Japan in the 1960s [23], the 5'S is a systematic technique, belonging to "Lean Manufacturing", that companies use with the aim of order, organize and properly clean the workplace and thus improve both efficiency and productivity [24]. Likewise, the definition of 5'S emphasizes the simplification of the work environment, the reduction of waste that affects process times and the management of production areas, thus creating a better management culture and competent personnel [25]. This methodology comprises 5 principles, the first of which is “Seiri” (sort) where what is necessary is separated from what is obsolete, “Seiton” (set in order) to efficiently organize tools or merchandise, “Seiso” (shine) to carry out cleaning in the work area, “Seiketsu” (standardize) where previous tests are carried out so that the results achieved are standardized and “Shitsuke” (sustain) where it is established that the improvements must remain continuous [26].

With respect to the execution of the 5'S, it is possible to maximize productivity up to 55% and reduce operator movements by 40% [27]. Furthermore, in terms of storage management, obsolete products are eliminated by up to 25% [28], as well as maximizing occupied space in the warehouse by 30% [29].

Systematic Layout Planning (SLP):

Developed for the first time in 1973 by Richard Muther, this tool facilitates the identification, evaluation and visualization of the different physical elements (equipment, machines, etc.) and spaces that make up the area to be intervened to obtain an efficient distribution [30]. Likewise, its implementation requires identifying the company's management strategy, warehouse restrictions, type of merchandise, travel time and distances within the area [31]. Also, it is important to define specific objectives that are aligned with the storage strategy that needs to be implemented [32]. On the other hand, it is considered that its application in warehouses provides an optimization of the processes carried out in the area to be intervened and identifies the best strategy for an efficient storage configuration [33].

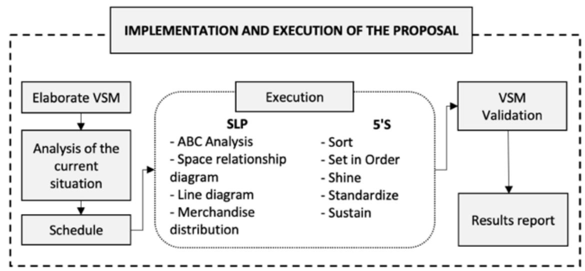
Regarding the expected results, it is considered that these vary depending on the context where it is implemented. On the one hand, its application in warehouse companies has resulted in an increase in the free area for storage of 18% and a decrease in the distances traveled by 5%, thus maximizing the efficiency of the processes [34]. On the other hand, if it is applied in the warehouse of a company that belongs to a different sector, there are improvements in storage space between 6% - 24% [35] and an improvement in picking times of 28% [36].

CONTRIBUTION

This proposed model is developed based on the “Lean Warehouse Management” philosophy represented by the application of Lean concepts in warehouse management, with the purpose of identifying activities that consume resources, but do not generate value, and eliminate waste [37]. Likewise, it offers warehouses the benefit of improving their efficiency, reducing the frequency of errors and maximizing the space available for goods, thus managing to adapt to sudden changes in customer needs and specifications [38].

The present model (Fig. 1) applied this philosophy in the warehouse management of the investigated company focused on the processes of both merchandise storage and picking, with the objective of reducing the delivery rate of late orders, optimizing the location of products on shelves and train workers to improve their performance.

Fig. 2: *Solution proposal model*



It should be noted that the innovation of this proposal lies in the fact that the VSM, 5'S and SLP tools will be adapted in their application for MSE companies in the logistics and storage sector that are recently integrating into the sector or that have expansion plans, to thus establishing a basis for storage management improvement. The model began by carrying out the VSM (Fig. 2) of the processes of both merchandise storage and picking/packing for the distribution of orders, including both operations in a single diagram and identifying their respective quantitative data (time recording, number of operators, demands, among others), thus obtaining a diagnosis in a current and realistic way.

In accordance with Fig. 3, it was observed that both for the processes of reception, verification and location of the merchandise, as well as the registration of said products in the ERP software, administrative operations, preparation of the order (picking/packing), distribution to the customer and delivery verification had a cycle time of 60, 240, 120, 20, 10, 35, 90 and 2 minutes, respectively. Likewise, the processes of reception, verification and location of merchandise showed a waiting time (lead time) of 1 day, respectively, in the same

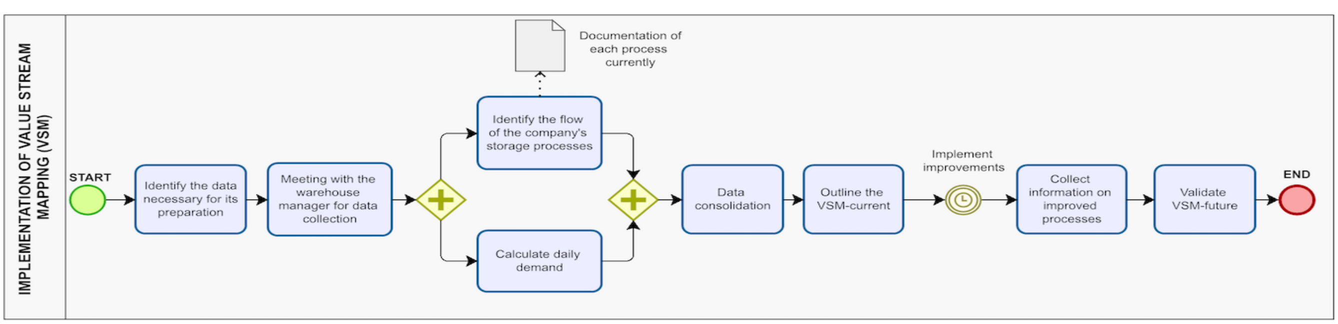


Fig. 1: *Value Stream Mapping (VSM) implementation flowchart*

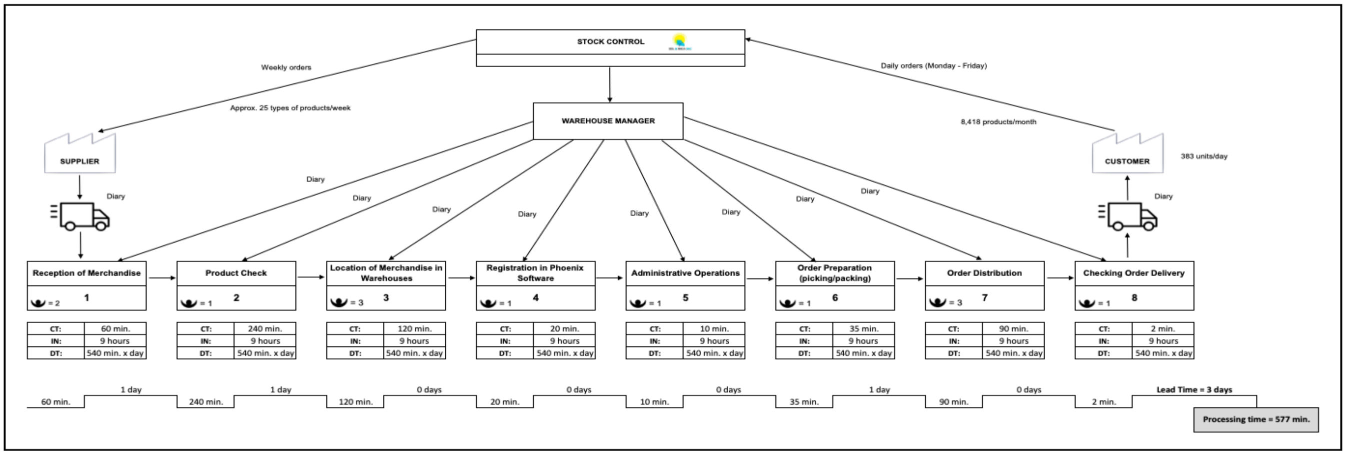


Fig. 3: *Value Stream Mapping (VSM) – current processes under study*

way for the activities of order preparation (picking/packing) and its shipment to the end customers, resulting in a total of 3 days of lead time and 577 minutes for the total process time in general.

On the other hand, the implementation of the SLP continued (Fig. 4) applying the ABC categorization to all the stored merchandise, with the purpose of selecting the warehouse that presented the greatest number of category A products (product with the greatest number of units distributed). As a result, warehouse No. 06 was intervened, as it had stored 14.04% of the merchandise belonging to said category. Next, a recognition of all the characteristics of the warehouse was carried out through a layout, where it was distinguished that it had 18.41 m², 9 shelves and 3 floor-type storage rooms. In addition, it was proven that, through a space and thread relationship diagram, it was necessary to obtain quick access to the merchandise in order to reduce picking times.

Subsequently, the information collected was analyzed and the relocation of the products was designed (Fig. 5), resulting in 110 SKUs (217 units) that needed to be relocated or discarded and 257 SKUs (8044 units) to be relocated. In addition, the remaining SKUs were relocated between the 9 shelves, considering that category A merchandise must be located on level B or C of the shelves closest to the access door (shelf No. 01 and No. 09), of the same Likewise, category B products. Also, category C products (low demand) must be reassigned as far as possible from the entrance to the area.

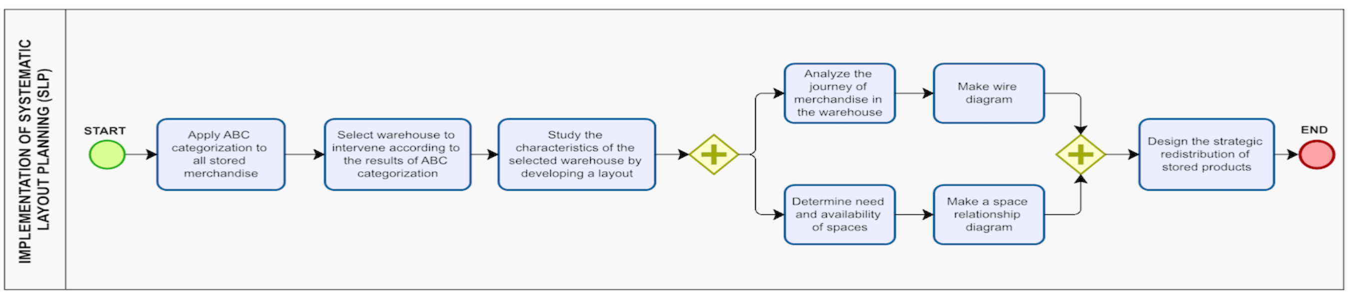


Fig. 4: *Systematic Layout Planning (SLP) implementation flowchart*

LEGEND			
NUMBER OF SHELVES	CATEGORY x TOTAL PRODUCT CODES (%)		
	A	B	C
Shelving N°01	9.76%	17.07%	73.17%
Shelving N°02	0.00%	10.00%	90.00%
Shelving N°03	0.00%	17.50%	82.50%
Shelving N°04	0.00%	9.52%	90.48%
Shelving N°05	0.00%	10.00%	90.00%
Shelving N°06	0.00%	0.00%	100.00%
Shelving N°07	0.00%	11.11%	88.89%
Shelving N°08	0.00%	6.45%	93.55%
Shelving N°09	12.90%	16.13%	70.97%

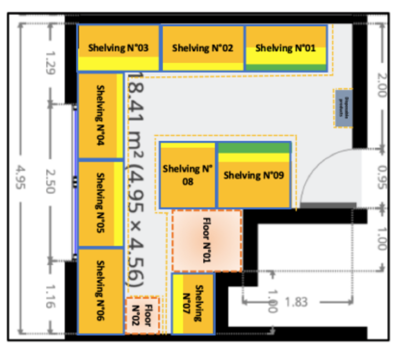


Fig. 5: *Layout of warehouse No. 06 by percentage of occupancy (%) according to the ABC categorization of products relocated and stored after the implementation of the Systematic Layout Planning*

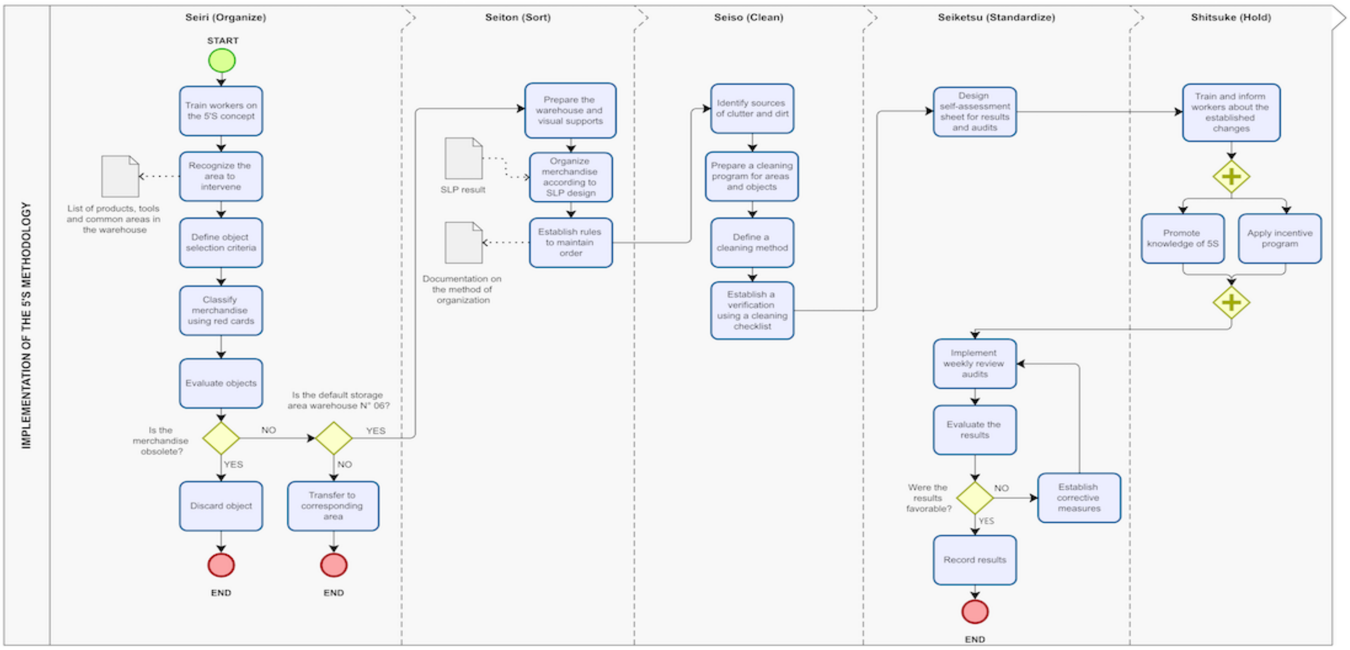


Fig. 6: *Flowchart of 5'S implementation*

On the other hand, before beginning the execution of 5'S (Fig. 6), initial training was carried out for warehouse operators regarding the concepts related to said methodology and thus reduce the risk of resistance to change. In addition, surveys were carried out before and after the training, with the purpose of evaluating how much the workers understood the concepts covered. Therefore, if both results are compared (Table 1), it is summarized that the participants finished the instruction with a greater understanding of the 5'S in each of its phases, on average an improvement of 37% was achieved in their responses.

TABLE 1: *Comparative table between the percentages (%) of correct answers given before and after the first training*

COMPARATIVE TABLE OF PERCENTAGE (%) OF CORRECTNESS IN THE RESPONSES TO THE QUESTIONNAIRES		
QUESTIONS	BEFORE TRAINING	AFTER TRAINING
Question N°01	60%	80%
Question N°02	40%	100%
Question N°03	40%	100%
	40%	80%
Question N°04	100%	100%
Pregunta N°05	60%	80%
	40%	100%

Consequently, improvements were made to the warehouse in accordance with the provisions of the 5'S methodology, which were carried out in five phases.

Phase N°01: Seiri (sort)

A "red card" design was developed for the stored products indicating their general information (date, warehouse number, name, quantity and description of the product, SKU (Stock Keeping Unit) and the name of both the operator who makes the observations and the person responsible of executing the required actions), indicating the brand and business line of the product (in accordance with the classification proposed by the supplier) to subsequently carry out the required actions, such as separating, eliminating, relocating, repairing, recycling or returning, ending with a comment or observation by part of the operator and establishing the end date of the action to be carried out (Fig. 7).

Fig. 7: *Implementation of Phase N°01: Seiri (sort)*

Phase N°02: Seiton (set in order)

Thanks to the SLP tool, the merchandise was distributed strategically and the map of the renovated warehouse layout was placed according to the ABC categorization of the stored products. Likewise, the resource of "green stickers" and location signs for shelves was used as a way of visual support for operators when carrying out the picking process, as well as adhesive tapes for the floor, in order to respect the sectoral limits of the area, thus achieving an effective organization (Fig. 8).

Fig. ***8:*** *Implementation of Phase N°02: Seiton (set in order)*

<u>Phase N°03: Seiso (shine)</u>

The company's operators used various special hygiene liquids to eliminate the dirt found both on the shelves and in the circulation spaces, establishing that this activity must be carried out once a week. Likewise, to corroborate the correct execution of said task, the "Cleaning Checklist" resource was used, establishing that each operator has the function of delivering the warehouse correctly clean and organized, thus completing the list with their full name, marking the boxes. the statements and ending the document with their respective signature (Fig. 9)

Fig. ***9:*** *Implementation of Phase N°03: Seiso (shine)*

<u>Phase N°04: Seiketsu (standardize)</u>

To standardize what was established in previous steps, weekly audits were established that were carried out throughout the observation time of the 5'S implementation. For these audits, it was necessary to design a self-assessment sheet for compliance with the 5 phases and the results were analyzed using a radar diagram (Fig. 10).

<u>Phase N°05: Shitsuke (sustain)</u>

In order to maintain the changes made, a final training session was carried out for the workers where the concepts of 5'S were further explored, the established improvements were explained and their questions were resolved. In addition, a rewards program was established for employees who complied with the schedule of actions implemented in the previous phases.

Fig. ***10:*** *Implementation of Phase N°04: Seiketsu (standardize)*

SOL & MICA SAC	**5'S AUDIT**		Warehouse:		
			Edition:		
			Revision number:		
Inspection data					
Group: ____ Leader: ____			Date: ____		
Item to evaluate	**Assigned values**				
	1	**2**	**3**	**4**	**5**
SORT					
1. Is there merchandise in poor condition?					
2. Is there merchandise that needs to be relocated?					
3. Are circulation areas blocked?					
4. Are there unnecessary tools in the warehouse?					
TOTAL SCORE					
SET IN ORDER					
1. Are the spaces assigned to the merchandise being respected?					
2. Are "green stickers" used as a visual aid?					
3. Do location signs serve as a visual aid?					
4. Are the areas marked by the yellow tape being respected?					
TOTAL SCORE					
SHINE					
1. What is the degree of cleanliness of the warehouse?					
2. Do the shelves have oil spills?					
3. Do the shelves have traces of rusty metal?					
4. How clean are the floors?					
5. Are trash cans being used during storage?					
6. Are the cleaning checklists being carried out?					
TOTAL SCORE					
STANDARDIZE					
1. Were the first three S's applied correctly?					
2. How good is the work environment?					
3. Is the lighting adequate?					
4. Have the processes presented improvements?					
TOTAL SCORE					
SUSTAIN					
1. Are the first four S's being met?					
2. What is the level of motivation of the workers?					
3. Are cleaning standards being met?					
4. Are organizational standards being met?					
5. Is the programming of 5'S activities complied with?					
TOTAL SCORE					

Moreover, below are the performance measurement indicators according to the tools that were used throughout this solution proposal:

<u>Cycle time indicator:</u>

TABLE 2: *Cycle time percentage variation indicator*

<table>
<tr><th colspan="6">CYCLE TIME PERCENTAGE INDICATOR</th></tr>
<tr><th colspan="6">DEFINITION</th></tr>
<tr><td colspan="6">This calculation allows determining the variation in the amount of cycle time of the investigated processes after the solution model has been carried out with respect to the initial cycle time.</td></tr>
<tr><th colspan="6">GOAL</th></tr>
<tr><td colspan="6">Reduction of the general time of the processes of both merchandise storage and picking/packing for the distribution of orders</td></tr>
<tr><th colspan="2">FORMULA</th><th colspan="2">VARIABLES</th><th colspan="2">UNIT</th></tr>
<tr><td colspan="2">$Cycle\ time\ percentage\ change = \frac{Cycle\ Time\ N°01 - Cycle\ Time\ N°02}{Cycle\ Time\ N°01} \times 100$</td><td colspan="2">• Cycle Time N°01: Current cycle time
• Cycle Time N°02: Cycle time after model implementation</td><td colspan="2">Percentage (%)</td></tr>
<tr><th colspan="6">MANAGEMENT MANAGER</th></tr>
<tr><td colspan="6">Warehouse Manager</td></tr>
<tr><th colspan="2">TOOL</th><th colspan="2">MEASUREMENT AND REPORTING</th><th colspan="2">USERS</th></tr>
<tr><td colspan="2">Value Stream Mapping (VSM)</td><td colspan="2">• Measurement Frequency: Semiannual
• Responsible: Research Team
• Report: Semiannual</td><td colspan="2">• COO
• Warehouse Manager
• Research team</td></tr>
<tr><th colspan="6">GOAL</th></tr>
<tr><td>DEFICIENT</td><td>0% - 2%</td><td>REGULAR</td><td>3% - 5%</td><td>OPTIMUM</td><td>6% - 8%</td></tr>
</table>

According to the formula (Table 2), to develop the indicator it was necessary to obtain cycle time No. 1, which was determined thanks to the preparation of the VSM – Current, presenting a duration of 567 minutes. However, regarding cycle time No.2, it was only found after implementation and a result greater than 6% is expected.

Product search time indicator:

TABLE 3: *Product search time percentage variation indicator*

PRODUCT SEARCH TIME PERCENTAGE INDICATOR					
DEFINITION					
This indicator allows you to calculate the variability of the search time for the products requested by customers after executing the solution model with respect to the current one.					
GOAL					
Minimize product search time in the picking process					
FORMULA		VARIABLES		UNIT	
$\text{Search time percentage change} = \frac{\text{Search time N°01} - \text{Search time N°02}}{\text{Search time N°01}} \times 100$		• **Search Time N°01:** Current product search time • **Search Time N°02:** Product search time after implementation of the model		Percentage (%)	
MANAGEMENT MANAGER					
Warehouse Manager					
TOOL		MEASUREMENT AND REPORTING		USERS	
5'S		• **Measurement Frequency:** Semiannual • **Responsible:** Research Team • **Report:** Semiannual		• COO • Warehouse Manager • Research team	
GOAL					
DEFICIENT	0% - 28%	REGULAR	29% - 49%	OPTIMUM	50% - 70%

According to this formula (Table 3), it was crucial to determine the duration of the search time for the current product in the selection process, both before and after the improvement. Additionally, a minimum 50% improvement in search time is expected to be achieved.

Indicator of products outside their assigned location:

TABLE 4: *Indicator of percentage variation of the total number of products outside their assigned location*

PERCENTAGE INDICATOR OF THE TOTAL NUMBER OF PRODUCTS OUTSIDE THEIR ASSIGNED LOCATION					
DEFINITION					
This indicator allows us to measure whether the operators are respecting the locations assigned in the second "S" stage belonging to the 5'S methodology.					
GOAL					
Reduce the percentage of products found outside their established location					
FORMULA		VARIABLES		UNIT	
$\text{Percentage of products outside their assigned location} = \frac{\text{Total number of products outside their assigned location}}{\text{Total number of products}} \times 100$		• Number of products outside their established location • Total number of products		Percentage (%)	
MANAGEMENT MANAGER					
Warehouse Manager					
TOOL		MEASUREMENT AND REPORTING		USERS	
5'S		• **Measurement Frequency:** Semiannual • **Responsible:** Research Team • **Report:** Semiannual		• COO • Warehouse Manager • Research team	
GOAL					
DEFICIENT	8% or more	REGULAR	5% - 7%	OPTIMUM	0% - 4%

According to the proposed formula (Table 4), there were 121 SKUs outside their assigned place, obtaining a current result of 32.35%. Likewise, the objective was set to reduce this value to 2%.

Freed space indicator:

TABLE 5: *Freed space percentage change indicator*

PERCENTAGE INDICATOR OF RELEASED SPACE					
DEFINITION					
This indicator serves to detail the percentage of the storage area (m²) that has been freed after implementing the improvement proposal					
GOAL					
Measure the freed space (m²) on warehouse shelves					
FORMULA		VARIABLES		UNIT	
$\text{Percentage of freed space} = \frac{\text{Total meters gained } m^2}{\text{Total meters } m^2} \times 100$		• Totale meters gained (m²) • Total meters (m²)		Percentage (%)	
MANAGEMENT MANAGER					
Warehouse Manager					
TOOL		MEASUREMENT AND REPORTING		USERS	
Systematic Layout Planning (SLP)		• **Measurement Frequency:** Semiannual • **Responsible:** Research Team • **Report:** Semiannual		• COO • Warehouse Manager • Research team	
GOAL					
DEFICIENT	0% - 4%	REGULAR	5% - 9%	OPTIMUM	10% - 14%

According to this formula (Table 5), the warehouse did not have meters gained, since it is at 100% occupancy. However, once the model has been carried out, it is desired to obtain a percentage greater than 12% as a target result.

VALIDATION

The current state of warehouse No.06 was studied, to subsequently implement the improvement proposal, that is, make changes based on the VSM, 5'S and SLP tools, and thus analyze its performance over a period of four weeks. Likewise, as a result of the validation process, an improvement in the indicators was recognized, which were:

Percentage variation in cycle time:

Improvements were detected in the VSM – future, such as the reduction of the storage cycle time to 95 minutes and picking/packing to 21 minutes, leading to a final result of 538 minutes of order distribution time and a reduction in lead time to 2 days. In addition, a result of 6.76% was obtained in the percentage variation of the cycle time, exceeding the 6% objective (Table 6).

TABLE 6: *Final result of the cycle time percentage indicator*

CYCLE TIME PERCENTAGE INDICATOR		
VARIABLES	VALUE	UNIT OF MEASUREMENT
Cycle Time N°01	577 minutes	Percentage (%)
		FORMULA
Cycle Time N°02	538 minutes	(577-538)/577 = **6.76%**
GOAL		
DEFICIENT	REGULAR	OPTIMUM
0% - 2%	3% - 5%	6% - 8%

Percentage variation in product search time:

As a result of the implementation of 5'S, an optimization of the search time to 5 minutes was achieved. Likewise, the performance of said tool was evaluated using the formula for the percentage variation in the search time for products requested by the client. Therefore, a result of 61.54% was obtained in the percentage variation, exceeding the 50% objective (Table 7).

TABLE 7: *Final result of the product search percentage indicator*

PRODUCT SEARCH TIME PERCENTAGE INDICATOR		
VARIABLES	VALOR	UNIT OF MEASUREMENT
Search Time N°01	13 minutes	Percentage (%)
		FORMULA
Search Time N°02	5 minutes	(13-5)/13 = **61.54%**
GOAL		
DEFICIENT	REGULAR	OPTIMUM
0% - 28%	29% - 49%	50% - 70%

Percentage variation of products outside their assigned location:

There was a variation of 28.88% of this indicator with respect to the result obtained before making the improvements (32.35%). Likewise, of the 374 stored products, it was detected that only 13 were found outside their assigned location at the end of the supervision stage (Table 8).

TABLE 8: *Final result of the percentage indicator of the total number of products outside their assigned location*

PERCENTAGE INDICATOR OF THE TOTAL NUMBER OF PRODUCTS OUTSIDE THEIR ASSIGNED LOCATION		
VARIABLES	VALOR	UNIT OF MEASUREMENT
Number of products outside their established location	13 products	Percentage (%)
		FORMULA
Total number of products	374 products	13/374 = **3.48%**
GOAL		
DEFICIENT	REGULAR	OPTIMUM
8% or more	5% - 7%	0% - 4%

The final result of this indicator was 3.48%, being within the optimal performance range (0% – 4%). However, the stated objective of 2% was not achieved.

<u>Percentage variation of freed space:</u>

The shelves have a total of 21.48 m² of storage space, of which 2.16 m² were freed up. Therefore, according to the validation results, it presents an occupancy of 89.94% in shelves after the improvement, since 10.06% of the storage space was freed. Furthermore, this result is within the optimal range (10% – 14%), but the objective of 12% was not reached (Table 9).

TABLE 9: *Final result of the percentage indicator of freed space*

PERCENTAGE INDICATOR OF RELEASED SPACE		
VARIABLES	VALOR	UNIT OF MEASUREMENT
Meters gained (m²)	2.160 m²	Percentage (%)
		FORMULA
Total meters (m²)	21.48 m²	2.16/21.48 = **10.06%**
GOAL		
DEFICIENT	REGULAR	OPTIMUM
0% - 4%	5% - 9%	10% - 14%

On the other hand, audits were carried out before and after the application of the model, with the purpose of validating that each phase of the 5'S was implemented successfully. For this, the radar graph (Fig. 12) was used as a performance meter.

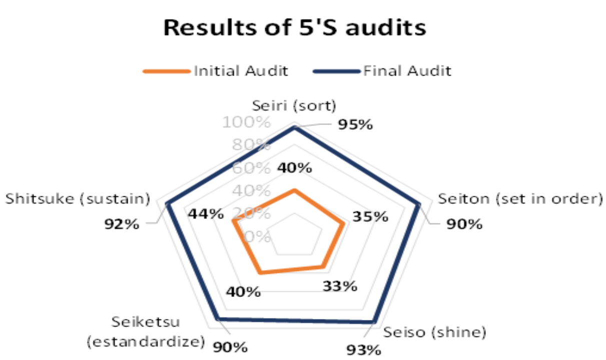


Fig. 12: *Radar diagram of the results obtained in the 5'S methodology audits*

In summary, it was observed that there is an improvement of 53.6% on average in each phase, thus confirming the success in the implementation of said methodology in the merchandise storage and picking/packing processes. Finally, the improvement in the delivery rate of late orders was validated, whose pre-implementation improvement value was 14.69%, presenting a total of 333 late orders in 2021.

TABLE 10: *Final result of the percentage indicator of delivery of late orders*

PERCENTAGE RATE OF LATE ORDER DELIVERY		
VARIABLES	VALOR	UNIT OF MEASUREMENT
Number of late orders	84 orders	Percentage (%)
		FORMULA
Total number of orders	2,267 orders	84/2,267 = **3.71%**
GOAL		
DEFICIENT	REGULAR	OPTIMUM
16% or more	7% - 15%	0% - 6%

The revised index now stands at 3.71%, with 84 late orders, reflecting a percentage variation of 10.98% (Table 10). Consequently, the company adheres to the maximum percentage stipulated by the importing supplier of 6%. Furthermore, a student's t-test was employed to statistically verify the impact of the model implementation on the company. Two hypotheses were utilized for this purpose:

- **H0:** There is no significant difference in the number of late orders between the baseline measurement and the measurement at the end of implementation.
- **H1:** There is a significant difference in the number of late orders between the baseline measurement and the measurement made at the end of implementation.

Additionally, the number of weekly late orders observed in the 4 weeks pre and post implementation was considered, and the Microsoft Excel data analysis tool was utilized to derive the following results (Table 11).

TABLE 11: *Results of t-test for means of two paired samples*

"T" TEST FOR MEANS OF TWO PAIRED SAMPLES		
Measures	Pre implementation	Post implementation
Mean	4.75	1.75
Variance	2.916666667	2.25
"t" statistic	7.348469	
P (T≤t) two tailed	0.005208	
Critical value of "t" (two-tailed)	3.182446	

A significant impact on the company was demonstrated, with the significance level (0.0052) below 0.05, leading to H0 rejection. Additionally, the t statistic (7.35) exceeded the critical value (2.92), further supporting H0 rejection. Post-implementation values showed lower mean and variance, indicating improved weekly late order numbers.

On the other hand, the economic performance of the company was analyzed post-implementation across pessimistic, expected, and optimistic scenarios. Consideration was given to the total implementation budget (S/ 3,529), operational expenses (S/ 37,569), financial expenses (S/ 446), and monthly fixed profit (S/ 52,779). Additionally, an Opportunity Cost of Capital (COK) value of 5% was utilized [39].

TABLE 12: *Results of the financial indicators in the pessimistic, expected and optimistic scenarios*

SCENARIOS	PESSIMISTIC	EXPECTED	OPTIMISTIC
VAN	S/11,147.94	S/12,659.30	S/16,185.81
TIR	40.43%	45.03%	55.79%
PAYBACK	3 Months	3 Months	2 Months

Accordingly, the 3 financial scenarios (Table 12) presented positive results in the net present value (NPV) and the internal rate of return (IRR), which meant that the project is economically viable and reflected short-term gains. However, they vary in the payback (recovery period), since in the pessimistic and expected scenarios the investment would be recovered in a period of 3 months, compared to the optimistic scenario where 2 months were needed. In summary, the model had a significant impact on the company, with the investment expected to be recouped within 3 months. Additionally, the improvement resulted in an NPV of S/ 12,659 and an IRR of 45.03%, demonstrating positive outcomes for warehouse MSEs.

ARGUMENTATION

After the Value Stream Mapping (VSM), a 6.76% variation in distribution process cycle time was achieved. However, Ref. [7] on a paint manufacturer's warehouse, this was reduced to 15.71%. This reduction was attributed to strategic signage, improved customer relationship management, visual control during merchandise stacking, and barcode scanning for product inspection. Furthermore, Ref. [16], in their research on a fruit distribution center, achieved only a 0.29% reduction in the variation. This minimal improvement is attributed to the company's adherence to the FIFO (First in, first out) criterion, where products are sold in the order they were received.

In the application of 5S, a 61.54% variation in product search time during picking was achieved. However, Ref. [26], a lower result of this indicator (27.06%) was attained, as only 5S was utilized as an improvement tool without complementing it with SLP. Likewise, Ref. [25], intervened in a plastic bag manufacturer, results of 66.67% and 51.95% were achieved for the reduction in search time for each caliper and printing blocks, respectively. Similarly, after the 5S supervision period ended, only 3.48% of objects were found outside their designated locations. This result is lower than the 5% achieved Ref. [4], where they applied Lean Warehousing in a perishable products warehouse with high turnover, facing challenges in maintaining merchandise order.

Using the SLP tool, a 10.06% improvement (2,160 m²) in freed warehouse space for shelf storage was achieved. However, Ref. [34] attained a better result of 18.17% by employing a mathematical program to optimize merchandise storage in a warehouse with a single floor level. In contrast, Ref. [35] achieved a 24% improvement by exclusively targeting the warehouse of a manufacturing company and utilizing algorithms to determine real-time optimal storage methods based on market demand. Similarly, Ref. [36] achieved an 8% increase in freed space in a medical services company warehouse, employing tools and techniques similar to those used in the present investigation for medication reorganization.

Finally, based on the scientific articles analyzed during this research, it is proposed to complement this model with the Kaizen philosophy in future works in order to quantitatively verify the variation of the results obtained.

CONCLUSIONS

- The application of VSM resulted in a 6.76% variation in cycle time, surpassing the 6% objective.
- 5S implementation resulted in a 61.54% reduction in search time variation, surpassing the 50% objective. However, products outside their designated location were reduced to 3.48%, missing the 2% target.
- Using SLP, a 10.06% increase in freed space was achieved, totaling 2.16 m² cleared.
- The late order delivery rate was ultimately reduced to 3.71%, marking a 10.98% variation.
- The model's significant impact was validated via the student's t-test, with a significance level below 0.05, rejecting hypothesis 0.
- In summary, the proposal is economically viable, with positive NPV and IRR values of S/. 12,659 and 45.03%, respectively.

REFERENCES

[1] Nai Peru, "Estudio de Mercado Logístico - Perú," Online. Available: https://www.naiperu.com/files/archivos/Estudio_de_Mercado_Logstico.pdf, 2020.

[2] Banco Central de Reserva del Perú, "Reporte de inflación de diciembre del 2021: panorama actual y proyecciones macroeconómicas del 2021-2023," Online. Available: https://www.bcrp.gob.pe/docs/Publicaciones/Reporte-Inflacion/2021/diciembre/reporte-de-inflacion-diciembre-2021.pdf, 2021.

[3] INEI, "Informe técnico: producción nacional," Online. Available: https://www.inei.gob.pe/media/MenuRecursivo/boletines/03-informe-tecnico-produccion-nacional-ene-2021.pdf, 2021.

[4] M. Moreno and Y. Núñez, "Propuesta de mejora en la gestión de almacenes utilizando la metodología Lean Warehouse y la herramienta de asignación de mercadería para incrementar la rentabilidad en las empresas distribuidoras de productos de consumo masivos," M.S. thesis, Universidad Peruana de Ciencias Aplicadas, Peru, 2020. Available: https://repositorioacademico.upc.edu.pe/handle/10757/648835.

[5] K. Tangchaideeb and N. Kongprasert, "Lean Warehouse Management through Value Stream Mapping: A Case Study of Sugar Manufacturing Company in Thailand," in IEEE 8th International Conference on Industrial Engineering and Applications, 2021, pp. 1-5, https://doi.org/10.1109/ICIEA52957.2021.9436732.

[6] F. Riveros, M. Arango, W. Adarme, and J. Zapata, "Modelo de optimización de la asignación de espacios de almacenamientos en una empresa colombiana," Revista DYNA, vol. 86, no. 209, pp. 255-260, 2019. https://doi.org/10.15446/dyna.v86n209.77527.

[7] L. Socconini and M. Barrantes, El proceso de las 5'S en acción: la metodología japonesa para mejorar la calidad y la productividad de cualquier empresa, 3rd ed. Marge Books, 2020.

[8] K. Martin and M. Osterling, Value Stream Mapping: How to Visualize Work and Align Leadership for Organizational Transformation, 1st ed. McGraw-Hill Business Ali Naqvi, S., 2013.

[9] A. Fahad, M. Atir, M. Zubair, and M. M. Shehzad, "Productivity improvement of a manufacturing facility using systematic layout planning," Cogent Engineering, vol. 3, no. 1, 2016. https://doi.org/10.1080/23311916.2016.1207296.

[10] M. Marziali, A. Rossit, and A. Toncovich, "Warehouse management problem and a KPI approach: a case study," Management and Production Engineering Review, vol. 12, no. 3, pp. 51-62, 2021. http://dx.doi.org/10.24425/mper.2021.138530.

[11] Y. Prasetyawan and N. G. Ibrahim, "Warehouse improvement evaluation using lean warehousing approach and linear programming," IOP Conference Series: Materials Science and Engineering, vol. 847, no. 1, 2020. https://doi.org/10.1088/1757-899X/847/1/012033.

[12] C. M. Pereira, R. Anholon, I. S. Rampasso, O. L. G. Quelhas, W. Leal Filho, and L. A. Santa-Eulalia, "Evaluation of lean practices in warehouses: an analysis of Brazilian reality," International Journal of Productivity and Performance Management, vol. 70, no. 1, 2020. https://doi.org/10.1108/IJPPM-01-2019-0034.

[13] P. Dobos, Á. Cservenák, R. Skapinyecz, B. Illés, and P. Tamás, "Development of an Industry 4.0-Based Analytical Method for the Value Stream Centered Optimization of Demand-Driven Warehousing Systems," Sustainability, vol. 13, no. 21, 2021. https://doi.org/10.3390/su132111914.

[14] F. Ud Din, D. Paul, J. Ryan, F. Henskens, and M. Wallis, "AOSR 2.0: A novel approach and thorough validation of an agent-oriented storage and retrieval WMS Planner for SMEs, under Industry 4.0," Future Internet, vol. 13, no. 6, 2021. https://doi.org/10.3390/fi13060155.

[15] M. Salwin, I. Jacyna-Gołda, M. Bańka, D. Varanchuk, and A. Gavina, "Using value stream mapping to eliminate waste: A case study of a steel pipe manufacturer," Energies, vol. 14, no. 12, 2021. https://doi.org/10.3390/en14123527.

[16] A.P. Proença, P.D. Gaspar, and T.M. Lima, "Lean Optimization Techniques for Improvement of Production Flows and Logistics Management: The Case Study of a Fruits Distribution Center," Processes, vol. 10, no. 7, 2022. https://doi.org/10.3390/pr10071384.

[17] C.E. Pérez-Pucheta, E. Olivares-Benítez, H. Minor-Popocatl, P.F. Pacheco-García, and M.F. Pérez-Pucheta, "Implementation of lean manufacturing to reduce the delivery time of a replacement part to dealers: a case study," Applied Sciences, vol. 9, no. 18, 2019. https://doi.org/10.3390/app9183932.

[18] B. Suhardi, N. Anisa, and P.W. Laksono, "Minimizing waste using lean manufacturing and ECRS principle in Indonesian furniture industry," Cogent Engineering, vol. 6, no. 1, 2019. https://doi.org/10.1080/23311916.2019.1567019.

[19] E. Alzubi, A. M. Atieh, K. Abu Shgair, J. Damiani, S. Sunna, and A. Madi, "Hybrid integrations of value stream mapping, theory of constraints and simulation: Application to wooden furniture industry," Processes, vol. 7, no. 11, 2019. https://doi.org/10.3390/pr7110816.

[20] A. Abideen and F.B. Mohamad, "Improving the performance of a Malaysian pharmaceutical warehouse supply chain by integrating value stream mapping and discrete event simulation," Journal of Modelling in Management, vol. 16, no. 1, pp. 70-102, 2021. https://doi.org/10.1108/JM2-07-2019-0159.

[21] P. Raghuram and M.K. Arjunan, "Design framework for a lean warehouse: A case study-based approach," International Journal of Productivity and Performance Management, vol. 71, no. 6, 2021. https://doi.org/10.1108/IJPPM-12-2020-0668.

[22] P.G. Abhishek and P. Maheshwar, "Achieving Lean Warehousing Through Value Stream Mapping," South Asian Journal of Business and Management Cases, vol. 9, no. 3, pp. 387-401, 2020. https://doi.org/10.1177/2277977920958551.

[23] R.N. Magalhães, A.P.T. Costa, D.B. de Alencar, and A.E. Sanches, "Implementation of 5’S Methodology in Stock Area in an Electronics Factory in Manaus Industrial Polo," International Journal for Innovation Education and Research, vol. 7, no. 11, pp. 788-798, 2019. https://doi.org/10.31686/ijier.Vol7.Iss11.1933.

[24] S.A. Khan, M.A. Kaviani, B. Galli, and P. Ishtiaq, "Application of continuous improvement techniques to improve organization performance: A case study," International Journal of Lean Six Sigma, vol. 10, no. 2, 2019. https://doi.org/10.1108/IJLSS-05-2017-0048.

[25] M.M. Shahriar, M.S. Parvez, M.A. Islam, and S. Talapatra, "Implementation of 5’S in a plastic bag manufacturing industry: A case study," Cleaner Engineering and Technology, vol. 8, 2022. https://doi.org/10.1016/j.clet.2022.100488.

[26] O. Hirawati, A.K. Dea Legina, and H. Hamdi Azwir, "Improving Spare Part Storage to Reduce Searching Time by Implementing 5’S," Journal of Industrial Engineering Scientific Journal on Research and Application of Industrial Systems, vol. 7, 2022. http://dx.doi.org/10.33021/jie.v7i1.3685.

[27] A.C. Gavriluţă, E.L. Niţu, and C.A. Gavriluţă, "Algorithm to use some specific Lean Manufacturing methods: Application in an industrial production process," Processes, vol. 9, no. 4, 2021. https://doi.org/10.3390/pr9040641.

[28] J. Gutierrez, A. Santaolalla, A. Tercjak, N. Rojo, D. Encinas, Z. Gomez-de-Balugera, and G. Gallastegui, "Creating a green chemistry lab: towards sustainable resource management and responsible purchasing," Sustainability, vol. 12, no. 21, 2020. https://doi.org/10.3390/su12218934.

[29] A.A. Ahire, A.B. Chaudhari, O.S. Ahirrao, and V.B. Sarode, "Increasing Productivity Through Implementation of 5’S Methodology in A Manufacturing Industry: A Case Study," International Journal of Scientific Research in Multidisciplinary Studies, vol. 7, no. 7, pp. 51-57, 2021. https://doi.org/10.26438/ijsrms/v7i7.5157.

[30] A.P. Lista, G.L. Tortorella, M. Bouzon, S. Mostafa, and D. Romero, "Lean layout design: a case study applied to the textile industry," Production, vol. 31, 2021. https://doi.org/10.1590/0103-6513.20210090.

[31] S.E. Munive Silvestre, V.D. Paucar Chaicha, J.C. Alvarez Merino, and S. Nallusamy, "Implementation of a Lean Manufacturing and SLP-based system for a footwear company," Production, vol. 32, 2022. https://doi.org/10.1590/0103-6513.20210072.

[32] J. Saderova, L. Poplawski, M. Balog Jr., S. Michalkova, and M. Cvoliga, "Layout design options for warehouse management," Polish Journal of Management Studies, vol. 22, no. 2, 2020. https://doi.org/10.17512/pjms.2020.22.2.29.

[33] J. Saderova, A. Rosova, M. Sofranko, and P. Kacmary, "Example of warehouse system design based on the principle of logistics," Sustainability, vol. 13, no. 8, 2021. https://doi.org/10.3390/su13084492.

[34] P. Viveros, K. González, R. Mena, F. Kristjanpoller, and J. Robledo, "Slotting Optimization Model for a Warehouse with Divisible First-Level Accommodation Locations," Applied Sciences, vol. 11, no. 3, 2021. https://doi.org/10.3390/app11030936.

[35] S.E. McInerney and V.S.S. Yadavalli, "Increasing warehouse throughput through the development of a dynamic class-based storage assignment algorithm," South African Journal of Industrial Engineering, vol. 33, no. 2, pp. 157-167, 2022. http://dx.doi.org//10.7166/33-2-2651.

[36] A. Gurumurthy, V.K. Nair, and S. Vinodh, "Application of a hybrid selective inventory control technique in a hospital: a precursor for inventory reduction through lean thinking," The TQM Journal, vol. 33, no. 3, 2020. https://doi.org/10.1108/TQM-06-2020-0123.

[37] G. Richards, Warehouse Management: A Complete Guide to Improving Efficiency and Minimizing Costs in the Modern Warehouse, 2nd ed. Kogan Page, 2014.

[38] J. Bradbury, "What to Know About Lean Warehouse Management," Industrial Distribution (Online). [Online]. Available: https://wwwproquest.upc.elogim.com/trade-journals/what-know-about-lean-warehouse-management/docview/1855189513/se-2.

[39] P. Dagnino and D. Mateo, "Diseño de un modelo de gestión de operaciones basado en Lean Warehousing para mejorar la eficiencia operativa de almacenes logísticos" Tesis, Universidad Peruana de Ciencias Aplicadas, Repositorio académico de la Universidad Peruana de Ciencias Aplicadas. Available: https://repositorioacademico.upc.edu.pe/handle/10757/657148, 2020.