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Implementation of Lean Warehousing to reduce food waste of a Distribution Company

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Abstract— **According to recent research, the application of engineering approaches in distributors in the commercial sector needs to be improved. Likewise, there is evidence of a growing need for the analysis of processes in warehouses in order to reduce activities that do not generate value to increase profitability in companies. In the current study, a food distribution company was examined and a distribution system model focused on solving problems in the warehouse due to waste generated in each process was suggested. The main problem was identified as food losses in the storage area and a suitable solution was suggested to address it. For this, cross contamination must be reduced in the storage process and thus reduce the amount of products lost due to contamination of moisture products and reduce products lost due to improper location of products. Likewise, the amount of expired products in the picking process must be reduced. Finally, errors in the packing process must be reduced with standardized packing and stacking methods. Using the Lean Warehousing methodology, an improvement model was presented based on the integration of tools such as Slotting for Warehouse Control, Kanban, FEFO for perishables control, PokaYoke and Standard work for method error control. Currently, the company proposes a 6.65% reduction in losses in warehouse management and 3% is considered a limitation according to the literature.**

Keywords— logistics, lean warehousing, warehouse distribution, warehouse waste, lean principles, waste reduction

I. INTRODUCTION

Companies are continually changing all throughout the world, which raises output levels. This is a result of the competition between them, which forces them to constantly improve their procedures to provide items with additional value and win over customers [1].

The majority of businesses struggle with the efficiency of their warehouses and distribution facilities [2]. For a good position in the competitive market, it is important to have efficient storage, since it represents a large part of logistics costs [3].

Likewise, the search to improve warehouse operations is essential when you want to satisfy customer demands [4]. Therefore, having good logistics planning in a warehouse is of the utmost importance since higher levels of efficiency in processes and waste reduction are required, which will allow a better service to be provided [5].

Poor warehouse management generates an increase in financial restrictions, which leads to inventory deterioration, obsolescence, damage and losses. On the other hand, business managers have a basic understanding of management strategies that, when applied, will improve the way they run stores, which in turn will increase sales and profitability for their companies. [2]

In the commerce sector, there are few distributor companies that have presented innovations in their warehouses due to process analysis and costs. This problem is repetitive in the Peruvian market with all the competition. [13].

The use of Lean tools and techniques has proven to be effective when you want to reduce processes that do not generate value through the elimination of waste. One of the ideal lean tools for storage is found in the Lean Warehousing methodology [6]. The application of the Lean philosophy benefits in solving problems, and generating demand opportunities for its products through a better display of these [7]. The use of better segmentation in the classification and an adequate allocation of the products will achieve optimal spaces and improvements in the inventory management system [8].

On the other hand, the interest in investigating lean in storage and distribution operations would contribute to better performance and performance of their processes. Therefore, they would be reflected in logistics performance and throughout the distribution channel [9].

Choosing the right quantity to order and incurring related warehouse expenses are also part of warehouse management. Therefore, warehouses have reduced activities that don't provide value as a result of the increased requirement for improvement [10].

The motivation arises because there is a divided approach to food losses and waste in distribution companies [11]. Therefore, the main objective of this study is to design a model based on the Lean Warehousing methodology as a test in order to reduce shrinkage.

In the structure of this article, the high rate of shrinkage was identified as the main problem. Losses were found in the storage, packing and picking process. Therefore, the development of Lean Warehousing is proposed to reduce losses in the affected processes.

Next, success stories are evidenced in the state of the art to support the investigation. Next, the solution design is presented. Then, the validation of the design and its conclusions are shown. Finally, the bibliography from which the information was collected is shown.

II. LITERATURE REVIEW

2.1. Lean Warehousing operations

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Warehouse operations are critical components of competitive supply chains as they handle and store merchandise [12].

A fundamental part of supply chain management is storage; For this reason, a constant, systematic and above all measurable improvement is necessary through the collaboration of all the workers involved. Therefore, it is important to reduce waste in order to improve the supply chain. [13].

Therefore, the management must know in greater depth the detail of its warehouse so that it can exercise an efficient warehouse management. To do this, it must be determined whether the activities being carried out are necessary and whether the appropriate resources are used. [11].

The application of the Lean methodology within a warehouse has effective results such as reduced delivery times and increased added value to its products. Similarly, decisions to allocate storage positions have an impact on the efficiency and speed of order preparation execution. Therefore, the location of items will be influenced by the way you display them efficiently, reducing distances and times. [14].

The purpose of the Lean Warehousing methodology is to reduce activities that do not generate added value in those warehouse operations [15], which are:

Figure 1: Warehouse Operations

Receiving: This consists of unloading the products from the truck and registering what was received. Likewise, it must be inspected if the products received meet the conditions of the order request [16].

Put-away: This activity consists of locating the merchandise in the storage positions.

Picking: It consists of obtaining the products that are going to be sent in an order, based on a selected list; indicating the order information such as the product code, quantities, customer name and others [17].

Packing: consists of packing, packing the products that have been selected in the previous process for it to be sent to the client.

Dispatch: This last activity controls the complete output of an order, which goes through inspection and finally through the shipment ready for delivery. [18].

Therefore, it is necessary to propose a tool for any storage activity to reduce the time and costs of these operations. [19].

2.2 Lean Warehousing tools

Literature studies present different success stories in order to identify the most outstanding approaches for good warehouse management and determine their impact on various firms.

According to the authors' research [20], they show the application of the various principles of the Lean philosophy in a logistics management system in a particular case of a hypermarket store, with the aim of improving processes that involve different areas. such as the warehouse and the store. Therefore, for the authors, it is necessary to propose proposals to modify the replacement management system, as well as standardize the activities of the picking and replacement process and redesign the distribution of the warehouse area.

This resulted in a 28% reduction in the percentage of goods that needed to be replaced, a 25% reduction in staff hours spent on superfluous operations, and a 100-meter reduction in meters traveled throughout the picking process.

On the other hand, other authors [21] observe that inventory management is an important part of any company that is dedicated to the production of any product, so there should not be excess stocks or shortages of said inputs, these are the most common drawbacks in inventory management.

Likewise, these authors compiled the information of the company in the purchasing, production and sales processes in order to determine the current state of the company. Therefore, the ABC method was used to determine the most relevant products in terms of sales revenue and their rotation in the period 2018 to 2019. Finally, a periodic review model of (R, S) was carried out [22].

Similarly, storage is linked to slotting in terms of inventory management (physical and documentary). This methodology, also known as Storage Position Assignment, supports deciding where the location and accommodation will be together with order preparation. Taking into account the characteristics of the SKU'S (Stock Keep Units), the storage system, or the hierarchy of the products according to various analyses, such as ABC [5].

Similarly, decisions to allocate storage locations have an impact on the efficiency and speed of the order fulfillment operation. Consequently, the location of items will be influenced by the way you display them efficiently, reducing distances and picking times [23].

Other authors [24] mention applying a SLAP-VH model based on mathematical programming in a beverage distribution center, with the aim of reducing the time traveled by the cranes in order to reduce costs related to the picking process, as well as, the best use of the warehouse area.

Finally, it can be concluded that the distances of the routes between the different areas in the warehouse decrease by 4.64%. Likewise, the preparation time process of an order is reduced by 5%.

2.3 The food industry's wastes

According to the authors [19] mentions that the wastes in the distribution warehouses present a limiting percentage of 3%, and the occurrence of this occurs due to the lack of precision in inventory control, dispersion in the location of the products by classification, distribution of products and monitoring of products by periodicity [26].

The following authors [18], in their research seek to reduce the amount of waste in a company dedicated to the retail sale of food, through the implementation of an inventory management system, with the design of an inventory control policy. They seek to reduce the amount of waste of food products. The authors, by implementing an inventory management system, managed to reduce food fluctuation by 48%, availability increased by 2%, the purge rate was reduced by 43%, and order fluctuation was also reduced by a 43%

Finally, the researchers show the contribution of the tools, for the improvement in the warehouse systems and the reduction of unnecessary processes of the different companies. The proposals of approach of each methodology applied in the warehouses vary according to the needs of the companies, however, favorable results are obtained in their distribution and production processes

III. METHODOLOGY

The solution proposal is based on the Lean Warehousing philosophy approach. The model is aligned to the reduction of losses in the storage area. The methods they include are Slotting, Poka-Yoke, Standard Work, Kanban and FEFO. Therefore, different articles, success stories and previous studies are compared. The following table summarizes the studies that have been carried out.

Table 1: Comparison of authors and tools

Reference	Tools/ Methodologies	Result
[2]	Slotting	Picking times were optimized by 23%
[20]	Poka Yoke	Minimize or avoid errors and mismatches
[21]	Estandar work	1.17% reduction in time between distances
[23]	Estandar work	50% less workload
[24]	Kanban	Up to 7.78% waste reduction
[25]	FEFO	Reduction of delays by 28%

The authors [2], propose a slotting tool in a company that has a high percentage of unproductive time and expired products. This is caused by a lack of standardization of operations in the warehouse area, inadequate storage location, and inadequate inventory review.

The authors [21] propose the standard work tool in their warehouse management model, to improve the low efficiency that the case study presents. The result of the improvement is a 50% reduction in the workload and a reduction in order picking time, with an average of 75 minutes.

The authors [24], analyze the problem of excessive use of labels that is generated by printing. For this reason, it analyzes lean and Kanban techniques to determine improvement processes and minimize waste, obtaining a reduction of up to 7.78% and an increase in the indicators studied.

The authors [25], identify in this investigation, products that have an expiration date and a warehouse without signs and

surrounded by traffic. To deal with this situation, a product labeling process has been designed, an appropriate distribution technique is used in the warehouse through a new warehouse layout, and a First Expired, First Out system has been implemented. The results show that late deliveries were reduced from 38% to 10%.

3.1 Model Components

In the investigation, a solution model is proposed in order to reduce the rate of loss in the company. The solution proposal is based on the Lean Warehouse methodology. It should be noted that, for the selection of the tools to be used for the improvement, a VSM has been used to determine the diagnosis of the company, which allows understanding the distribution process, in which the cycle times and the shrinkage rate are highlighted. . The following figure 3 shows the company's current VSM

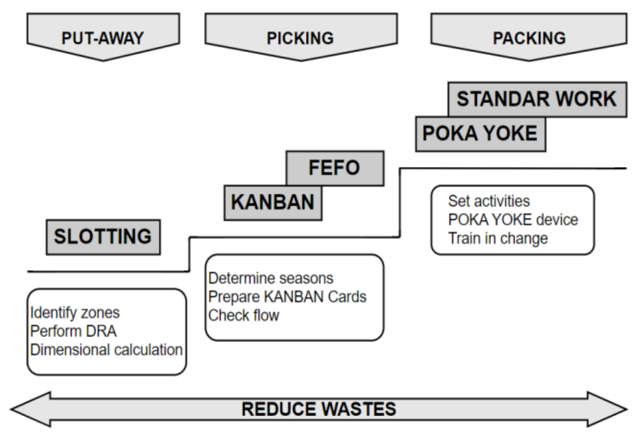

Figure 2: Lean Warehousing model

3.1.1 Put-away proposal

Waste control is crucial in the first process of operations to ensure that the warehouse is used to its full potential [19]. Slotting tools will be employed in this to reduce the effects of moisture contamination of items and insufficient storage site.

A correctly implemented Slotting system will make the best use of available space, simplifying mobility inside the warehouse for the following processes [20].

First, the ABC analysis was carried out to determine the products with the highest turnover. Then, safety stock calculations are performed to determine the amount of inventory by family type before placing an order [21].

The application of the slotting tool in the company consists of 11 steps. First, the collection of historical data is carried out, with the aim of identifying those products that generate the highest income in the organization. After that, the calculations of the revision intervals, permissible limits, replacement point and calculation of the replacement amount are made. Likewise,

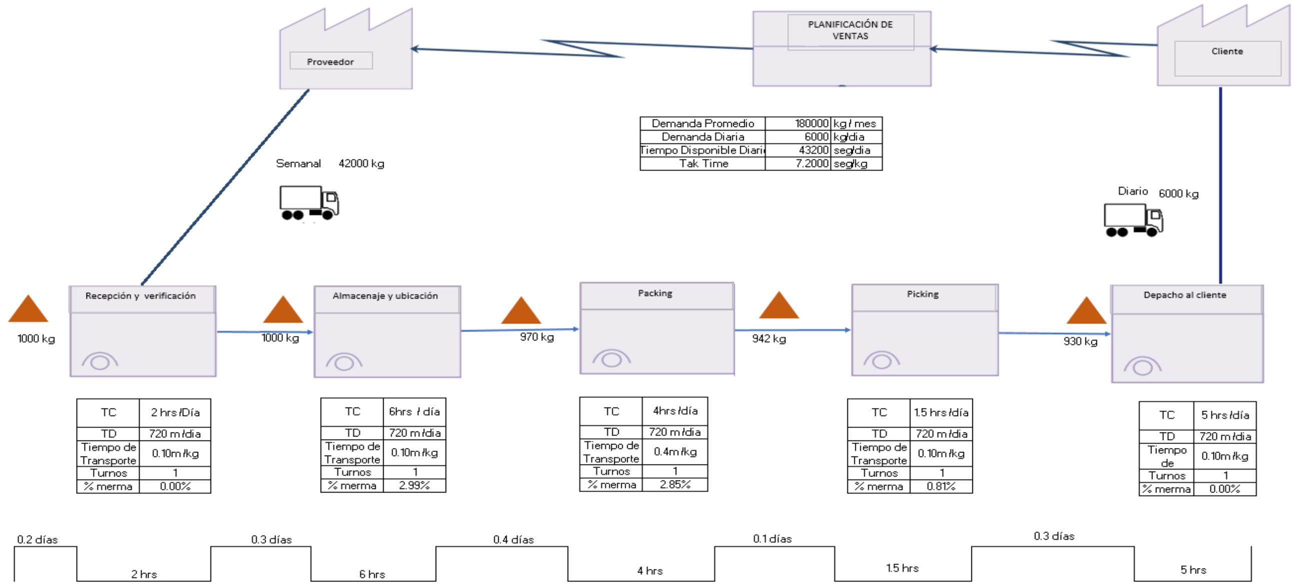

Figure 3: Current VSM

a training plan is carried out on issues related to the implementation and benefits of slotting. In addition, the monitoring of the metric and the verification of the improvement were carried out, through the analysis of the indicator before and after the implementation.

Likewise, the calculation of the reorder point was carried out with the objective of having an adequate location and replacement of the inventory [22]. Then, the warehouse was redistributed into class A products in green, class B in yellow and class C in red.

Item A: Represents approximately 70% of the turnover rate. For this reason, it is necessary to place them in an area of easy accessibility and that is close to the area of the picking process.

Item B: These items represent 20% of the turnover rate. It is important to give them a location area with easy accessibility.

Item C: These reflect the 10% turnover rate, and are placed in an area with normal accessibility and that is not an impediment to the activities carried out in the warehouse area.

Finally, a training plan is carried out to indicate the functions to be carried out with the monitoring of the merchandise rotation within the warehouse. In addition, the improvement is verified, through the analysis of the indicator before and after the implementation.

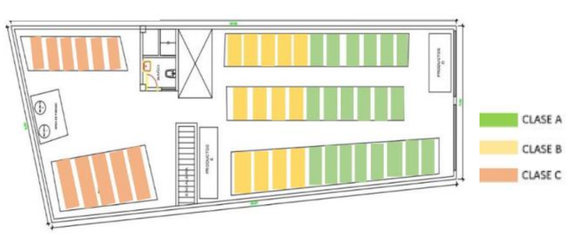

Figure 4: Proposal SLOTTING

Finally, a training plan is carried out to indicate the functions to be carried out with the monitoring of the rotation of merchandise within the warehouse. In addition, the improvement is verified, through the analysis of the indicator before and after the implementation, together with the training plan.

3.1.2 Picking tools

The integration of the policies and proper picking planning will help ensure proper warehouse management. As a result, it's important to maintain process optimization [23].

In the investigation, wastes were found in this process, due to a deficient selection of products. The implementation of the Kanban and FEFO tools was proposed.

The Kanban methodology has the purpose of generating alerts at the exit of a product from the warehouse, with the use of cards that allow to identify of the expiration time of the product. These cards must be placed as a mural in a visible place for collaborators, in order to identify those products that are about to expire [24].

Likewise, to complement the methodology, the implementation of training and an inventory format is proposed, in order to have the amount of physical stock mapped. Finally, the standardization of the activities in the picking process is carried out. Finally, the model is used and the implementation results are verified using a VSM after implementation. [2]

Nombre de Tarjeta	Colores	Vida Útil
Tarjeta 1	Verde	6 meses
Tarjeta 2	Amarillo	3 meses
Tarjeta 3	Rojo	1 mes

Figure 5: Proposal KANBAN

The implementation of FEFO aims to reduce the number of non-compliant orders for expired products [25]. Therefore, the use of cards marked FEFO was made to indicate the expiration date of the products. Thus, those who are about to expire will be released.

3.1.3 Packing proposal

Packing is an essential phase in the logistics chain since it enables products to arrive to the client at the end of the distribution process in perfect condition. [26]

The Poka-Yoke tool was implemented, in order to control the errors that occur in the packing process. On the one hand, the development of the tool seeks to improve the packaging method to avoid errors in this process [20].

The first step of the methodology is to empathize, which consists of raising awareness of the benefits that are generated after implementation. Then the process to be improved was selected in order to collect the necessary information. After that, the activities carried out in the packaging process are analyzed. Finally, a Poka-Yoke device is proposed, the anti-spill pallet.

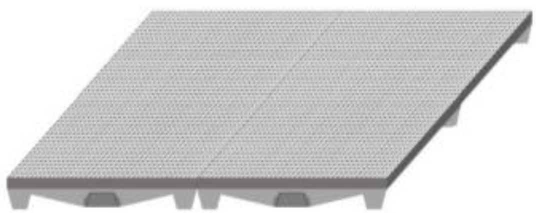

Figure 6: Anti-spill pallet

The purpose of implementing an anti-spill pallet is to reduce the amount of waste generated by the packaging method.

This device fulfills the function of containing those grains that fall without control at the moment of weighing; Likewise, it fulfills the function of protecting them against contaminating agents from the floor; for so; Maintain the safety of the raw material. This pallet is stainless steel material.

In addition, the development of the implementation of the Standard Work will be used to identify the activities that generate waste in the stacking process.

Mainly, a DAP of the stacking method was carried out, in which 11 operations activities, 6 transport and 1 storage were obtained. Then an AVA matrix was made to determine those activities that generate added value, in which it was determined that activities 2,3,5,11, and 18 should be eliminated, thus obtaining a 27% reduction in transfer times.

After that, a training plan is carried out with the objective of providing knowledge to the collaborators of the implementation steps. Finally, the codification, verification and elaboration of a standard model are carried out.

3.2 Expected results

The indicators to determine the values of the root causes are important since they will support measuring the current situation and the situation after the implementation.

The following indicators have been proposed to establish the target value, the literature of different authors has been reviewed. On the one hand, the first indicator has a goal of 4.8%. Likewise, in the indicator of % of products lost due to inadequate location, a goal of 3.40 % is established. The third indicator has a target of up to 4.9%. On the other hand, the indicated percentage of products lost in the packaging method establishes a goal of up to 3.5%. Finally, the last indicator has a goal of 3.5%.

Below is the table with its indicators:

Table 2: Metrics

Affected	Metrics	before	after	Measurement	Investigation
Put-away	% of product contamination by moisture	15%	5%	Kg lost due to contamination / Total Kg	[2]
	% of products lost due to inappropriate location	8%	3%	Kg lost due to improper location / Total Kg	[26]
Picking	% of expired products	12%	5%	Kg of expired products / Total Kg	[21]
Packing	% of products lost in the packaging method	10%	4 %	Kg of lost products / Total Kg	[22]
	% of products lost in the stacking method	9 %	4 %	Kg of lost products / Total Kg	[13]

IV. VALIDATION

4.1 Case study

The analysis of the problem in the company was carried out, which was identified as the main problem to the high rate of losses, having a 3% rate of losses. According to the literature found [11], the optimal value of the shrinkage index is 3% in distribution warehouses. Likewise, the economic impact of the problems represents S/.1,052 thousands soles of economic loss per year, which represents 6.69% of the total costs.

Information was collected and quantified from the records for the year 2021, according to the inventory warehouse reports. Three reasons were found: Cross contamination in the storage process, expired product in the picking process and error in the packing process.

On the other hand, the losses for the affected processes were calculated. In the storage process, 2.99% wastage was obtained, in the packing process, 2.85% wastage was obtained and in the picking process, 0.81% wastage.

4.2 Identification of affected processes

Information was collected and quantified from the records for the year 2021, according to the inventory warehouse reports. So, three reasons are found: Cross-contamination in the storage process, expired product in the picking process and error in the packing process.

The first reason has two fundamental causes: contamination of products by moisture and inadequate location in storage. It is evident as a problem since in the storage process it happens since the category A products move between unnecessary warehouses since an adequate location for the product families is not determined.

The second reason is due to expired products in the picking process. It is identified as the reason for the problem because there is a deficient selection of products; therefore, it is not possible to meet the necessary amount requested by the lawsuit. According to the calculation, this value is below 7.19% according to [27], the stockout value in the value of food inventories for a service level of 95% is 85.6%.

The last reason is the error in the packing process, which has two causes: the poor method of packing and stacking. The cause that originates this reason is based on the deficient selection of the product; that is to say that in the picking process, the collaborators do not have a defined process at the moment of selecting the products.

Table 3: Cause due to processes affected in the warehouse

Affected process	Reason	Causes
Put-away	Cross contamination in the storage process	Contamination of products by moisture
		Inadequate storage location
Picking	Expired product in the picking process	Poor product selection
Packing	Error in the packing process	Poor packaging method
		Poor stacking method

According to the analysis of the causes of the problem, it was possible to identify the causes that have the greatest impact on the company under study. Likewise, the economic impact for each cause was calculated, identifying that the causes of product contamination due to humidity, deficient product selection and deficient packaging method represent 84.23% of the total research problem.

On the other hand, the amounts lost in kg lost for each cause were calculated, and it is obtained that the cause with the greatest amount of kg lost is the contamination of products by humidity. In the same way, the economic impact was made for each cause per kg lost.

Next, the results of the application of the proposed model will be presented, supported by the indicators that approved a correct evolution.

4.3 *Design validation*

The implementation step begins with the announcement by top management. It is essential that those involved (administrative and collaborators) understand the benefits of developing a new tool for the company. Therefore, training schedules were prepared for the implementation of each Lean methodology, with the purpose that they can fill out the formats and calculate the metrics established by each process and its causes.

A test method for the simulation was then performed using Rockwell Automation's Arena Simulator software. The simulated part of the system that follows the functional model must be configured and tested to verify the results, whether its behavior will be close to or resemble the real system. It was developed under a confidence level of 95%.

The graphical representation of the investigation is focused on reflecting the discrete system to be simulated, with the corresponding limits with respect to what was diagnosed.

In this way, the processes of reception and verification, storage, packing, picking and dispatch to the client are considered, according to the problem of high rate of losses in distribution, which identifies the causes of losses found in each process. due to cross contamination, losses due to errors in the packing process, losses due to expiration in the picking process. Figure 3 shows the graphical representation.

Making a comparison of the As Is results and the To be system scenarios. In a pessimistic scenario, the number of completed correct tons increases up to 1,700 by 1.2% compared to As Is, and the percentage of losses with respect to production reduces up to 5.5%. On the side of the moderate scenario, the number of completed correct tons increases up to 1,730 by 3% compared to As Is, and the percentage of losses with respect to production reduces up to 4.35%. Lastly, in an optimistic scenario, the number of completed correct tons increases to 1,760 by 4.8% with respect to As Is, and the percentage of losses with respect to production reduces up to 2.74%, since this scenario meets the objective of solution to the research problem.

The To Be simulation system consists of proposing 3 improvement scenarios: Pessimistic, Moderate and Optimistic, where each one is based on the research metrics and traffic light indicators proposed, for which improvement assumptions are proposed to validate if there is an improvement. for the problem of the case study. It is worth mentioning that the results of each scenario will be analyzed within the 95% confidence level, therefore, the number of replications will be calculated.

4.3 Results

The To Be simulation system consists of proposing 3 improvement scenarios: Pessimistic, Moderate and Optimistic, where each one is based on the research metrics and traffic light indicators proposed, for which improvement assumptions are

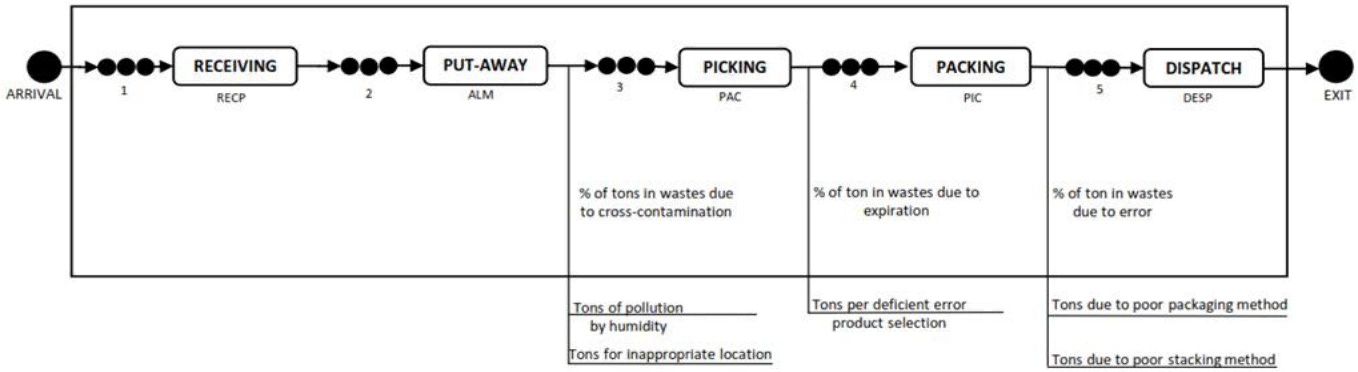

Figure 6: Graphic representation

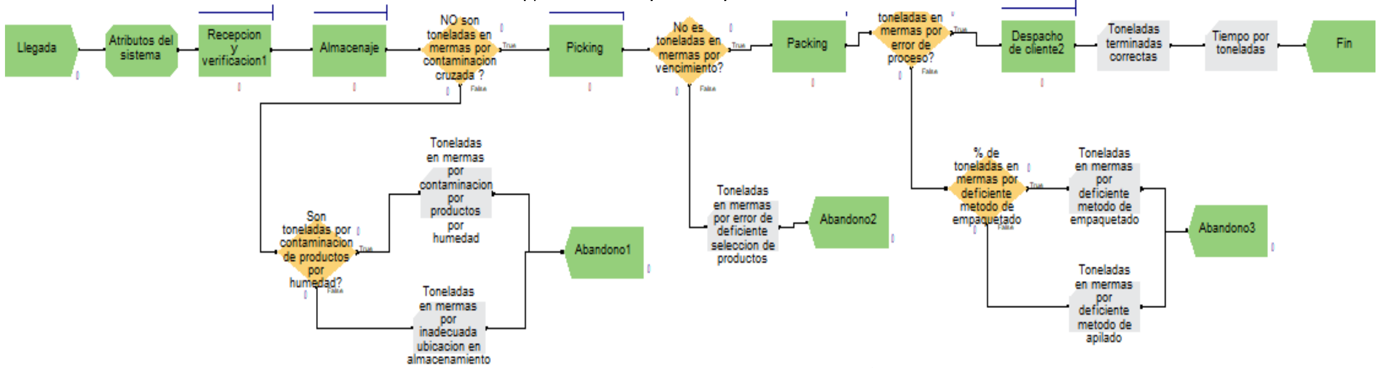

Figure 7: Current state simulation

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Making a comparison of the As Is results and the To be system scenarios. In a pessimistic scenario, the number of completed correct tons increases up to 1,700 by 1.2% compared to As Is, and the percentage of losses with respect to distribution reduces up to 5.5%. On the side of the moderate scenario, the number of completed correct tons increases to

1,730 by 3% compared to As Is, and the percentage of shrinkage is reduced to 4.35%. Lastly, in an optimistic scenario, the number of finished correct tons increases to 1,760 by 4.8% with respect to As Is, and the percentage of losses with respect to distribution reduces up to 2.74%, since this scenario meets the objective of solution to the research problem.

Table 3: Results by sensitivity scenarios

Metrics	*As is*	*Pessimistic*	*Moderate*	*Optimistic*
Time per tons	2.06	2.06	2.06	2.06
Correct finished tons	1,680	1,700	1,730	1,760
Porcentual increment		1.2%	3.0%	4.8%
Tons in wastes due to contamination by products due to humidity	49.20	46.00	38.10	24.90
Tons in losses due to deficient stacking method	10.20	7.30	6.19	4.83
Tons in losses due to deficient packaging method	13.50	10.20	8.45	5.82
Tons in losses due to poor selection of products	33.30	22.30	16.40	9.00
Tons in losses due to inadequate storage location	8.08	7.74	6.14	3.68
Total tons in wastes	114.28	93.54	75.28	48.23
% of wastes with respect to distribution	6.80%	5.50%	4.35%	2.74%
Porcentual increment		-18.15%	-34.13%	-57.80%

In this way, with the validation of the simulator, the sensitivity scenarios were proposed, verifying that the improvement in said processes allows reducing the technical gap of 3%.

V. DISCUSSION

This section will analyze the impacts of activities that do not add value to warehouse processes, as well as the different techniques used to reduce warehouses in distributors.

5.1 News and results scenario

This article demonstrates that activities that do not generate value in warehouse operations have different impacts and in small proportions.
as a result of some poorly performed process optimization.
One of the findings identified in the company was that delivery times are related to waiting waste in previous processes and unnecessary movements in the warehouse.
Therefore, the waste in the other warehouse operations, such as storage and dispatch, although no food losses were identified, also present long waiting times due to a lack of optimization of activities and established methods. Therefore, it is evident that all the wastes read have an impact on the different warehouse operations. [28]

The application of Lean Warehousing methodologies can improve waste and conditions for an optimal flow of resources in the warehouse. With the implementation of an inventory control system, it is more favorable and quickly to find the required products as it was in the company under investigation. Likewise, with training for the warehouse manager for the use of report sheets and use of lean techniques for the affected areas, an optimization of the activities was found and the same of the lean wastes found.

According to [29], they found that the most relevant waste was the waiting times in the storage process and it was solved with a Lean Warehousing multi-method approach.

VI. CONCLUSIONS

This research, after a long review of literature and the sector, shows the lack of innovation in food distributors, which is why the application of Lean tools is proposed to reduce waste in their warehouses.

The investigation proposes an improvement model based on the tools of lean Warehousing by slotting, kanbam, fefo, poka yoke and standard work to improve the problem due to the rate of loss in the processes warehouse affected, which are storage, picking and packing.

According to the diagnosis and the literature, the implementation by Slotting will be carried out to make improvements in the storage process, the implementation by Kanban and FEFO to improve the picking process, and the implementation by Poka yoke and Standard Work to improve the packing process.

Carrying out the validation of the simulator, the sensitivity scenarios are proposed, verifying that the improvement in said processes allows reducing the technical gap, being that in the pessimistic scenario a loss index of 5.5% is calculated, for the moderate scenario an index of losses of 4.35%, on the side of the optimistic scenario, a loss rate of 2.74% is calculated.

In this way, according to the results for the improvement scenario, the economic validation was carried out, giving results that the project does not present economic risks through the financial indicators for net present value and internal rate of return, where for the moderate scenario it is obtained a return of S/. 76,100 and due to the optimistic scenario, a return of S/. 185,115.

REFERENCES

[1] P. Perico, E. Arica, D. J. Powell, and P. Gaiardelli, “MES as an enabler of lean manufacturing,” IFAC-PapersOnLine, vol. 52, no. 13, pp. 48–53, 2019, doi: 10.1016/j.ifacol.201gonz9.11.306.

[2] de Jesus Pacheco, D. A., Møller Clausen, D., & Bumann, J. (2023). A multi-method approach for reducing operational wastes in distribution warehouses. International Journal of Production Economics, 256(November 2022). https://doi.org/10.1016/j.ijpe.2022.108705

[3] Abushaikha, I., Salhieh, L., & Towers, N. (2018). Improving distribution and business performance through lean warehousing. International Journal of Retail and Distribution Management, 46(8). https://doi.org/10.1108/IJRDM-03-2018-0059

[4] Perotti, S., Bastidas Santacruz, R. F., Bremer, P., & Beer, J. E. (2022). Logistics 4.0 in warehousing: a conceptual framework of influencing factors, benefits and barriers. International Journal of Logistics Management, 33(5), 193–220. https://doi.org/10.1108/IJLM-02-2022-0068

[5] de Oliveira, A. V., Pimentel, C. M. O., Godina, R., Matias, J. C. de O., & Garrido, S. M. P. (2022). Improvement of the Logistics Flows in the Receiving Process of a Warehouse. Logistics, 6(1), 22. https://doi.org/10.3390/logistics6010022

[6] Nedra, A., Néjib, S., Boubaker, J. y Morched, C. (2021). An Integrated Lean Six Sigma Approach to Modeling and Simulation: A Case Study from Clothing Process Mapping SME. Autex Research Journal. https://doi.org/10.2478/aut-2021-0028

[7] ur Rehman, A., Ramzan, M. B., Shafiq, M., Rasheed, A., Naeem, M. S., & Savino, M. M. (2019). Productivity improvement through time study approach: A case study from an apparel manufacturing industry of Pakistan. In Procedia Manufacturing (Vol. 39, pp. 1447–1454). Elsevier B.V. https://doi.org/10.1016/j.promfg.2020.01.306

[8] Accorsi, R., Baruffaldi, G. y Manzini, R. (2018). Picking efficiency and stock safety: A bi-objective storage assignment policy for temperature-sensitive products. Computers & Industrial Engineering, 115, 240–252. https://doi.org/10.1016/j.cie.2017.11.009

[9] Chauhan, C., Dhir, A., Akram, M. U. y Salo, J. (2021). Food loss and waste in food supply chains. A systematic literature review and framework development approach. Journal of Cleaner Production, 295, 126438. https://doi.org/10.1016/j.jclepro.2021.126438

[10] Kiraz, A., Cengiz Toklu, M., & Adali, M. R. (2021). A new approach to westinghouse tempo rating system with fuzzy Logic. Endüstri Mühendisliği, 32(1), 55–68. https://doi.org/10.46465/endustrimuhendisligi.809160

[11] Kumar, S. y Mahapatra, R. P. (2021). Design of multi-warehouse inventory model for an optimal replenishment policy using a Rain Optimization Algorithm. Knowledge-Based Systems, 231, 107406. https://doi.org/10.1016/j.knosys.2021.107406

[12] Tavill, G. (2020). Industry challenges and approaches to food waste. Physiology & Behavior, 223, 112993. https://doi.org/10.1016/j.physbeh.2020.112993

[13] Bottani, E., Volpi, A. y Montanari, R. (2019). Design and optimization of order picking systems: An integrated procedure and two case studies. Computers & Industrial Engineering, 137, 106035. https://doi.org/10.1016/j.cie.2019.106035

[14] Trindade, M. A. M., Sousa, P. S. A. y Moreira, M. R. A. (2021). Ramping up a heuristic procedure for storage location assignment problem with precedence constraints. Flexible Services and Manufacturing Journal. https://doi.org/10.1007/s10696-021-09423-w

[15] Guimarães, R., Almeida, L., Barros, M., Afecto, M. C., Figueira, M. L., Mota, D., Galvão, M., Barreira, M. y Lima, R. M. (2022). Restructuring picking and restocking processes on a hypermarket. Production Engineering Archives, 28(1), 64–72. https://doi.org/10.30657/pea.2022.28.08

[16] Cabrera-Gala, R., Carreón-Nava, L., Valencia-Cuevas, H. y Rivera-Sosa, L. (2021). Application of periodic review inventories model in a typical mexican food company. Acta logistica, 8(1), 27–36. https://doi.org/10.22306/al.v8i1.199

[17] Todorovic, V., Maslaric, M., Bojic, S., Jokic, M., Mircetic, D. y Nikolicic, S. (2018). Solutions for More Sustainable Distribution in the Short Food Supply Chains. Sustainability, 10(10), 3481. https://doi.org/10.3390/su10103481

[18] Wang, X., Rodrigues, V. S. y Demir, E. (2019). Managing Your Supply Chain Pantry: Food Waste Mitigation Through Inventory Control. IEEE Engineering Management Review, 47(2), 97–102. https://doi.org/10.1109/emr.2019.2915064

[19] Freitas, A. M., Silva, F. J. G., Ferreira, L. P., Sá, J. C., Pereira, M. T. y Pereira, J. (2019). Improving efficiency in a hybrid warehouse: A case study. Procedia Manufacturing, 38, 1074–1084. https://doi.org/10.1016/j.promfg.2020.01.195

[20] Ewita, H., Ali Tosa, F., Santoso, Y., Herliani Kusumah, L. y Yetti, H. (2019). Application poka-yoke to capture defect (A case study in industry component otomotive). International Journal of Industrial Engineering, 6(1), 14–17. https://doi.org/10.14445/23499362/ijie-v6i1p103

[21] Kumar, R., Chauhan, P. S., Kumar Dwivedi, R., Pratap Singh, A. y Prasad, J. (2022). Design and development of ball dispenser Machine through lean manufacturing tool Poka-Yoke technique in automobile industries. Materials Today: Proceedings. https://doi.org/10.1016/j.matpr.2022.04.335

[22] Abhishek P.G. y Pratap, M. (2020). Achieving lean warehousing through value stream mapping. South Asian Journal of Business and Management Cases, 9(3), 387–401. https://doi.org/10.1177/2277977920958551

[23] Samuel, R., Rajesh, M., Rajanna, S. y Franklin, E. (2021). Implementation of lean manufacturing with the notion of quality improvement in electronics repair industry. Materials Today: Proceedings. https://doi.org/10.1016/j.matpr.2021.04.200

[24] Yener, F., & Yazgan, H. R. (2019). Optimal warehouse design: Literature review and case study application. Computers and Industrial Engineering, 129(January), 1–13. https://doi.org/10.1016/j.cie.2019.01.006

[25] Najlae, A., Sedqui, A. y Lyhyaoui, A. (2021). A product driven system to facilitate FEFO application in warehouses. Procedia Computer Science, 191, 451–456. https://doi.org/10.1016/j.procs.2021.07.056

[26] Perotti, S., Bastidas Santacruz, R. F., Bremer, P., & Beer, J. E. (2022). Logistics 4.0 in warehousing: a conceptual framework of influencing factors, benefits and barriers. International Journal of Logistics Management, 33(5), 193–220. https://doi.org/10.1108/IJLM-02-2022-0068

[27]Asghar, M. A., Asghar, M. A., Rehman, A. A., Khan, K., Zehravi, M., Ali, S., & Ahmed, A. (2019). Synthesis and characterization of graphene oxide nanoparticles and their antimicrobial and adsorption activity against aspergillus and aflatoxins. Latin Am J Pharm, 38(5), 1036-1044

[27] Ali U, Salah B, Naeem K, Khan AS, Khan R, Pruncu CI, Abas M, Khan S. Improved MRO Inventory Management System in Oil and Gas Company: Increased Service Level and Reduced Average Inventory Investment. Sustainability. 2020; 12(19):8027. https://doi.org/10.3390/su12198027

[28] Salhieh, L., Altarazi, S., Abushaikha, I., 2018. Quantifying and ranking the "7—deadly" Wastes in a warehouse environment. TQM J. 31 (1), 94–115. https://doi.org/10.1108/TQM-06-2018-0077.

[29] Singh, M., Rathi, R., Antony, J., & Garza-Reyes, J. A. (2023). Lean Six Sigma Project Selection in a Manufacturing Environment Using Hybrid Methodology Based on Intuitionistic Fuzzy MADM Approach. *IEEE Transactions on Engineering Management*, *70*(2), 590–604. https://doi.org/10.1109/TEM.2021.3049877